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Exploring the Antecedents of Fast Digital Transformation Of Museums in the Context of Covid-19 Pandemic

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Museums are cultural institutions with an important role in preserving history and tradition. Every museum institution, at micro or macro level, strives to become relevant as an institution for the community, for a wide range of visitors, of different ages, identities and social classes. One possible way to achieve this goal may be to adapt the "language" used by museums to achieve their goals: mainly conservation, education and recreation, with the help of technology and especially technologies based on artificial intelligence (AI), through digital transformation. Four antecedent conditions leading to outcome has been addressed in this study: social media, Augmented Reality, Virtual Reality and AI powered chatbots

Introduction

Museums are cultural institutions with an important role in preserving history and tradition. But simple caring for objects is irrelevant if there is not at least one person who needs that object (Samis and Michelson, 2016). In this sense, there is a global struggle today to reduce the gap between the specific objectives of a museum and its relevance in the consciousness of the community. Every museum institution, at micro or macro level, strives to find the solution to close this gap, to become relevant as an institution for the community, for a wide range of visitors, of different ages, identities and social classes. New and innovative ways of getting in touch with visitors (physical and online) and potential visitors are needed.

The restrictions imposed by the Covid-19 pandemic further deepened the feeling of the presence of this gap, especially where the connection with the public was deficient or at a primary level and the relevance to the community could not be demonstrated or quantified.

One possible way to achieve this goal may be to adapt the "language" used by museums to achieve their goals: mainly conservation, education and recreation, with the help of technology and especially technologies based on artificial intelligence (AI), through digital transformation. Some changes are indeed needed to adapt the collections to the tools offered by AI, but their use will bring countless opportunities to discover and experience the "hidden" treasures in the museum's permanent exhibition and repositories, in completely new, captivating ways for the public and which, on the whole, improve the experience of visitors to museums and increase the degree of satisfaction, but also of community responsibility for the institution.

This change is especially needed for young audiences - the main target of most museums. Adolescents are an audience whose attention is very difficult to capture, especially in museums, as they are usually more interested in social interactions between them than in cultural content (Giuliano et all, 2019). Research in the US has shown that since 2017, already 95% of young people say they have a smartphone or have access to one, 45% of them say they are online almost constantly (Anderson & Jiang, 2018), and the method of socialization the most frequently used by young people aged 18-29 is "online chat" (Statistics, 2017). In the light of these data, it becomes clear that in order to capture the attention of young people,

museums will have to use the tools they use, understand their needs and let them explore at their own pace, but constantly surprising them with something new.

The aim of this research is to obtain relevant information on how digital transformation in the cultural heritage sector should be carried out, using AI technologies, in 3 steps:

1. an analysis of the main benefits of implementing AI technologies in the current activity of museums;
2. a study on good practices from museums that have taken on the digital transformation as their main objective and record successful results in implementation, on 3 continents: Europe, USA and Australia;
3. a series of fsQCA analyzes based on an online questionnaire addressed to museum managers in several European countries to see how the level of preparation for the digital transformation of museums is self-assessed, given 4 previous conditions: social media, augmented reality (AR), virtual reality (VR) and AI-powered chatbots.

Theoretical background

The use of technology in museums - generalities

Museums are sacred spaces where culture and history are protected and explored. In order not to remain obsolete in expression, museums use technology to connect with modern times and to improve their ways of achieving their goals (Berger, 2017). The use of technology by museums for this purpose is not new. Museums' concern for technology has always existed, especially to bring visitors to the manifestations of technology over the centuries, from Paleolithic or Bronze Age household objects to a state-of-the-art computer, all designed to make it easier. tasks and to improve outcomes (Hunt, 1998; Ciolfi, 2005).

The technology has been used both to improve the form or content of specific exhibitions or installations, to meet the increasingly diverse requirements of visitors (Zheng et all, 2005), and to develop those tools that facilitate work in areas such as: security, access control, control and conservation of the environment in museum spaces, etc.

The adoption of new technologies and the adaptation of working tools to the specifics of cultural institutions, helps museums to respond better, better adapted to the current needs of the public, in a paradigm shift as highlighted by Zheng et all (2005), emphasizing that: the public has moved from the curatorial to the educational area; the presentation of exhibitions must take the step towards dynamism; new technologies and new media are becoming more and more present in the life of museums, and the target group is the young generation; only the creative use of new technologies will increase the involvement of the next generation of visitors - young people.

Therefore, technology has been, is and will be an important factor in shaping the way museums are managed and the way visitors interact with them and with sheltered art objects (Kueh, 2016). A quality interaction of the visitor with the museum's collections will stimulate especially the learning (educational component), as demonstrated by the study coordinated by Rawat (2005), and the most obvious form of contemporary interaction is the digital type.

Given what has been said so far, we must mention that technology and its use must not be an end in itself or must never be its own justification (Lingxi, 2020). The technology should be used mainly to connect the public with museums and their collections, but without influencing the presentation of exhibits in the specific way of each museum.

Artificial intelligence (AI) and its relevance to museums

Among the commonly used technologies, those based on AI offer the greatest opportunities for museums, both in terms of the visitor experience in the museum and the use and analysis of important data: collection information management, research and evaluation of visitors (Villaespesa & French, 2019); involvement and connection with them (Lingxi, 2020). The collection of this data, about collections, visitors and exhibitions, by traditional methods has been inaccessible to many small and medium-sized museums, due to the high costs and the necessary human resources. But, AI is a solution to all these problems.

AI is a tool used very often around us, but it is not exactly new. The term was coined by John McCarthy in 1956 (Villaespesa & French, 2019). He argued that every aspect of learning or any aspect of intelligence can be so well described in principle that a machine can be made to simulate it. Styx (2020) shows that although it was first developed in the 50s, the idea is not exactly new and can be traced back to the twentieth century. IV î. H., when Aristotle thought of Logic and Logistics and laid the foundations of the first formal deductive reasoning system. In the same research AI is defined as the study and design of the intelligent agent - a system that perceives its environment and takes measures that maximize its chances of success, using tools and perspectives in many fields: computer science, psychology, logic, linguistics, etc. Kean (2018) characterizes AI as a type of energy that sets things in motion and that underlies the operation, manufacture and use of many of the objects we use daily.

There is currently no widely accepted definition, but it is clear that all forms of technology and all specific tools lead to an acceleration of the various processes, which would otherwise require a large human resource and generate high costs. While some AI results are still raw and experimental, some applications already have functionality expected and often used by users: personalized recommendations, navigation by patterns or label, recognition of images or objects in a photo taken, or receiving a response to a vocal assistant (Cieko, 2019). The growing importance and relevance of AI for humanity is indisputable. It already underlies routine aspects of our lives, in ways we are not fully aware of, from the educational process (Kleijn & Siebert, 2020) to research, industry, public debate and the commercial sector, by: providing personalized marketing information; data transfer and cross-referencing; making decisions about insurance claims or even detecting financial fraud (Cieko, 2019).

Although the business sector is leading the way in innovative applications of AI technology, museums, cultural organizations and NGOs in general are increasingly trying to access the huge benefits of using AI.

How AI technologies are used to develop new tools to attract new visitors to the museum has been the subject of an extensive study, funded by the Knight Foundation in 2017, conducted in 12 art museums and presented by Butler (2017) . The main objective was: to identify new tools and approaches for the use of technology in the interest of museums. Using as interview tools the interview (with specialized staff from museums, leaders of digital departments, IT staff from museums) and a round table discussion (with professionals in the field of arts and culture, artists, entrepreneurs, professors and directors of museums) have reached the following conclusions: museums can and must learn from the implementation of technology in other sectors; the role of museums changes, diversifies and at the same time the experience lived by the visitor in the museum (physical or online) should change; digital transformation begins with infrastructure and organizational culture; sharing experiences is vital; free thinking of artists can lead to innovation.

In general, museums that have already implemented AI-based tools tend to use them more to improve and enhance the interaction between visitors and exhibits, between the

public and the museum, both on-site and online. Museums are constantly looking for new tools that can support this interaction, using increasingly diverse partnerships, as evidenced by a complex collaboration since 2019 between the Metropolitan Museum of Art in New York, MIT-Institute of Massachusetts Technology and Microsoft (Kinsella, 2019).

But AI-based technology can also be extremely useful in museum operations, such as: researching, evaluating, and predicting visitor behavior (Styx, 2019; Murphy & Villaespesa, 2020); visitor forecasting and predictive analysis (Murphy & Villaespesa, 2020); analysis of feelings by interpreting and quantifying the comments of visitors on specialized sites (Villaespesa & French, 2019); data analysis for collection information management (Bordoni et all, 2016); streamlining the operation of the security system and optimizing the consumption of energy and other resources (Styx, 2019).

Chatbots

In general, the term „chatbot" refers to a computer-developed program designed to mimic the conversation, using auditory or textual methods (Gaia et all, 2019), a software application that engages in dialogue with a human being, using natural language (Hill et all, 2015), generally through written text, but with significant progress in recent years and in speech recognition (Dale, 2016). This conversational system is based on natural language processing (NLP) and AI specific technologies.

Gaia et all (2019) defines NLP as the ability of a computer to analyze, understand and generate human discourse. Nowadays most NLP techniques are based on machine learning (Murphy & Villaespesa, 2020), and the most common applications are: content labeling, sentiment analysis, voice to text conversion and vice versa and translation services (French, 2018).

Nowadays there are all kinds of applications, capable of doing almost anything, but one of the most important and useful is chatbot technology, which has as its main objective, as we have seen, to answer people's questions. The concept is widely used today especially in the commercial sector, with the main purpose of interacting with customers to respond, direct them in the right direction and process their responses, with a major impact on reducing staff costs.

The major advantage of chatbots is that they are constantly improving as they "learn" (new data is introduced or assimilated from interactions) and can become faster and more efficient than human interfaces (Charr, 2019).

Experiments with chatbots in museums

We can say that chatbot technology is spreading globally today and is becoming more and more specialized, being used more and more in the museum sector to improve services. Museums have been coordinating AI and NLP-based programs for more than 20 years. Free chatbot platforms (Facebook Messenger, WhatsApp, Twitter, etc.) offer small and medium-sized museums the opportunity to experiment with chatbots with relatively little effort, while keeping staff costs and resources low (Gaia et al, 2019). Most of the implementation examples in museums aim to provide better, more captivating and personalized services for visitors.

The first chatbot used in the museum sector, according to the information available online is **LEONARDO**, an AI interface of the historical character Leonardo da Vinci launched in 2002, at the Museum of Science and Technology "Leonardo da Vinci" in Milan, Italy. It aroused great interest as an innovative tool, although it had many limitations in the NLP (Boiano & Gaia, 2017).

MAX- is a conversation agent provided by the „Heinz Nixdor" Museum in Paderborn, Germany in 2004, which relates directly to visitors through a screen (Kölbl & Rosen, 2018), practically a first example of a virtual guide museum.

In 2009, the **"Tyrannosaurus Rex" exhibition**, organized by the Field Museum in Chicago, had its own Twetter account that, during the exhibition, gathered over 50,000 subscribers (Fuller, 2017).

Also in 2009, two virtual educators began their work at the Boston Science Museum - **ADA** and **GRACE**. They answered visitors' questions by suggesting exhibitions or even explaining the technology behind their operation (Murphy & Villaespesa, 2020).

OBJECT PHONE is an experiment of the Cooper-Hewitt Smithsonian Laboratories in New York, launched in 2013, when specialized staff offered the public a conversational system based on voice interaction (Char, 2019). The "Object Phone" allows anyone to access the Cooper-Hewitt collection using a phone. Once the indicated number is dialed you can choose from a number of options, including listening to descriptions of objects. It was a great success, especially since the proposed discussion takes place on several levels (Micah, 2016): converses with its subscribers; send messages once a day; can easily respond to user requests about objects in the exhibition; and when he needs assistance he sends a message to a better informed staff. Since 2013, Object Phone is constantly evolving, receiving updates and new features. This way it becomes smarter and by collecting as much data as possible about the tastes and preferences of its users, it will offer a more personalized content. The transition from SMS service to large messaging platforms (Messenger, WhatsApp, etc.) will connect it to a wide-open audience: the whole world and will make the Cooper-Hewitt Smithsonian collection in New York accessible globally.

RECOGNITION is a chatbot in the form of a game, made available to the public by the Tate Gallery of Modern Art in London (UK), in 2016, which combines the matching of works of art with state-of-the-art photojournalism (http://recognition.tate.org .uk). It was developed to win a contest, initiated by the Tate Art Gallery in partnership with Microsoft, aimed at digital creators to identify a form of AI that would allow the public to explore and understand the British Tate collection in several ways. Recognition scanned more than 30,000 digitized works of art to create pairs with photos taken and published by news agencies. For example, the program matched a photo published by Reuters of 2 women wearing makeup from 1660 with a similar composition (Styx, 2009).

In a national project in Scotland, in 2016, was created **GEN** (Cawston et all, 2017), a chatbot that also offers an interactive gaming experience, in which users must take care of a unique digital creature, diagnosing them the numerous ailments and then treating them for healing using real digitized objects in the collections of national museums in Scotland.

The **ANNE FRANK** chatbot was launched in 2017 at the Anne Frank Memorial Museum in Amsterdam, the Netherlands (http://www.annefrank.org/en/). It is an interface of the historical character, who uses the Facebook Messenger platform to provide information about his life, about the house, about the period in which he lived, as well as practical information for visitors (visiting schedule, ticketing, parking spaces, etc.). uses in-depth learning technology to provide personalized answers based on past successful answers (Charr, 2019; Gaia et all, 2019; Murphy & Villaespesa 2020).

ADVENTOUR is a chatbot that appeared in 2016, runs on the Facebook Messenger platform and is an innovative virtual guide based on an interesting mix of stories and games in an attractive version, designed to help explore four memorial houses in Milan, -a captivating and fun way. Users are guided through questions and answers from a place in the

center of Milan to the desired museum, using a chatbot, instead of human staff (Boiano et all, 2016). The developers targeted the young audience and relied on the growing interest of adolescents in competition, challenges and collaboration, focusing more on tasks to be performed, through which they acquire knowledge subliminally, than by simply exposing information or simple conversation.

SEND ME SFMOMA is the chatbot from the Museum of Modern Art in San Francisco. It works like an SMS service: the user sends a message containing the words "send me +… ..... (a word, color or emoticon), and the application sends an image with a piece of art related to the message sent. It is an accessible, personal and creative way to connect the public with the museum's impressive collection - over 35,000 works of art, of which only 5% can be exhibited simultaneously in museum galleries (Mollica, 2017).

IRIS + is a digital assistant launched in 2017 at the "Museum of Tomorrow" in Rio de Janeiro, Brazil, which uses information from databases as well as interaction with visitors to converse with them and connect them to social initiatives and environment, which focuses on improving the future (Styx, 2009), to build a more inclusive and fairer tomorrow.

The Carnegie Museums in Pittsburgh are enjoying the success of **ANDYBOT**, launched in 2018 on the Messenger platform and offering a captivating gaming experience. The interface of the historical character Andrew Carnegie, a successful entrepreneur, philanthropist and founder of the museums that bear his name, guides users through various activities and experiences, both on and off the site. The motivation behind ANDYBOT, in the form of a complex messaging application, was, according to Merrit (2018): the desire to change the experience spent in the museum, from the status of occasional visit, to the integration of museums in everyday life with day of users through fun digital experiences, but also an extensive study conducted in the Carnegie Museums on a sample of 300 visitors interviewed, which showed that only 2% of them had mobile applications for the museum installed on their devices, while over 98 % sent text messages during the visit.

Experiences with AR and VR technologies in museums

From the cases presented above we can conclude that the experiments with chatbots and AI-based tools implemented in museums, which we have researched so far, are fascinating, especially through interactivity, through an involvement of the public at an unprecedented level in history. museums. But the benefits of the digital transformation of museums do not stop there. The big gain will actually be barrier-free accessibility, which can be achieved through a mix of tools: social media, chatbots, AR and VR, as we see in the following 2 examples:

CHAT WITH MARIO PRAZ is developed by the "Mario Praz" Museum in Rome, Italy and runs on the Facebook Messenger platform (https://www.facebook.com/pg/marioprazchat/posts/) and on Instagram (https: // www .instagram.com / explore / locations / 1769398813274434 / mario-praz-chat /). Uses Mario Praz's virtual persona as an interface and talks to visitors about his collections (Vassos, 2016). The novelty is that it uses VR technology to attract online guests through more captivating interactions. For example: online visitors can follow clues and go on a treasure hunt, looking at images depicting each museum room on the bot's Facebook wall, or using VR devices for 360° images of museum rooms. which transforms the experience from one without too much enthusiasm, into a captivating one.

The Vann Abbe Museum in Eindhoven, the Netherlands, provides the public with **a robot dedicated to people who cannot physically visit the museum** (Murphy & Villaespessa, 2020). Through this tool, experimenting with museum visits and exploring works of art is possible, without leaving the user's own environment. If the user has access and the VR device, the experience becomes unforgettable. The music service offers 2 possibilities to visit: a visit on your own assisted by a music supervisor throughout the itinerary, who can answer questions or a comprehensive guided tour with explanations for each work of art. The use of the robot from Vann Abbemuseum has a wide addressability: people with locomotor disabilities, people from another country, school courses for more desired visits without the students having to leave the room (https://vanabbemuseum.nl/en/mediation / inclusion / museum-visit-with-robot), or any person who does not want or cannot leave the home for any reason.

Method

Fuzzy-sets qualitative Comparative Analysis (fsQCA) is a hybrid method that offers the opportunity to deal with causal configurations of antecedent conditions that affect an outcome. In this study, museums' resilience strategy is enabled by fast digital transformation; thus, the application of this method leads to insights regarding how digital transformation in the cultural heritage sector should be carried out. This method enables the outcome (self-assessment of museums' digital transformation readiness level) by considering both sufficient and necessary conditions and their degree of influence when designing specific tools and platforms for the implementation of digital transformation. Four antecedent conditions leading to outcome has been addressed in this study: social media, Augmented Reality, Virtual Reality and AI powered chatbots (Figure 1).

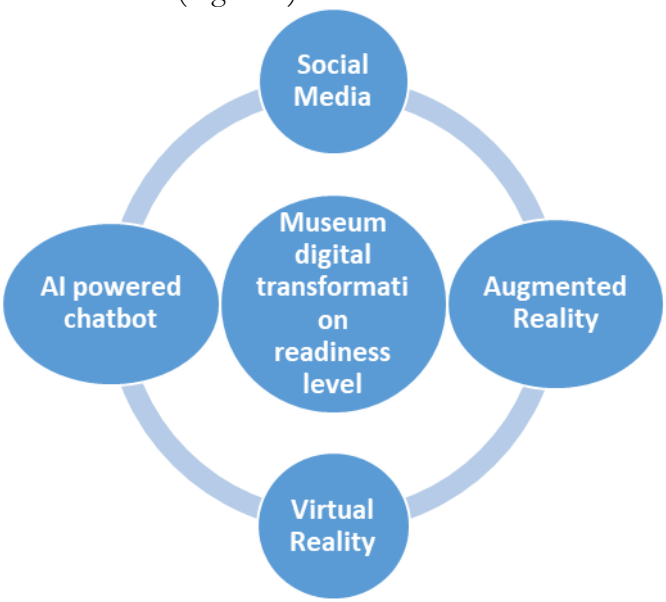

Figure 1 - Configurational research conceptual framework
Source: authors

Table 1 shows the antecedent conditions or factors used in fsQCA that strongly influence the digital transformation of museums. Four conditions have been considered, which encompass a total of twelve items, included in the online questionnaire submitted to managers of museums from different countries. They cover a wide range of issues, such as

museums' online branding strategies and virtual tours, enhanced by Augmented Reality and Virtual Reality tools, as well as AI-powered chatbots.

Table 1 - Research framework constructs description

Social Media	SM1: enabling virtual visitor engagement through increased average number of interactions per post
	SM2: enhancing museum's online branding strength through increased number of followers
	SM3: tracking scores given by virtual visitors on the review sections of museum's social media page
Augmented Reality	AR1: enhancing museums' displays by explaining the significance of cultural heritage objects
	AR2: offering downloadable apps to provide visitors memorable learning experiences
	AR3: capturing opportunities to reveal cultural heritage massive objects at scale (the dimensions in reality)
Virtual Reality	VR1: providing enjoyable, personalized information about cultural heritage objects through VR headsets
	VR2: overcoming physical constraints by offering a fully immersive experience in the museum atmosphere and story
	VR3: bringing museum collections to life by making the online exhibits interactive
AI powered chatbot	AIPC1: enabling enhanced experiences and saving virtual visitors time while searching specific collections
	AIPC2: offering valuable hints and information on visitor demand during their virtual tour
	AIPC3: enabling a gamification approach allowing a treasure hunt inside the virtual exhibit
OUTCOME	**Self-assessment of museums' digital transformation readiness level**

Source: authors

The respondents to the online questionnaire posted at https://forms.gle/73fd7yizmaPMR9xN7 are museums' managers or representatives from administrative teams, who kindly accepted the invitation to support this research. The respondents profiling considering the country where the museum is located reflects a distribution on several European countries: Italy, Spain, France, Germany, Romania, Malta, Portugal, United Kingdom, Portugal, Greece, Czech Republic, Belgium and Croatia. We received and validated 30 responses, a convenience sample considered sufficient for fsQCA analysis.

The calibration procedure is conducted using variables on 5 points Likert scales (Strongly agree to Strongly disagree) for the antecedent conditions. The conversion between Likert scales labels and the fuzzy scores is performed using different qualitative anchors, according to fsQCA method – Table 2. The fuzzy scores are associated with degree of membership and range from 0.05 (which outlines a low degree of agreement) to 1 (which reveals a high degree of agreement). The cross-over is set at 0.5.

Table 2 - Calibration of scales for antecedent conditions

Scale point	Fuzzy-set value	Membership
Strongly agree	1	Fully in
Agree	0.75	More in than out
Neutral	0.50	Cross-over (neither in nor out)
Disagree	0.25	More out than in
Strongly disagree	0.05	Fully out

Source: adapted from Ragin, 2014

In the case of the outcome, the calibration of scales takes into consideration five levels of digital transformation maturity model, adapted from De Carolis et al. (2017). Initial stage means that museums haven't and adequate digital infrastructure for creating virtual tours and exhibits; second stage outlines partially planned and implemented digital infrastructures, while the third stage highlight that the process is defined thanks to the planning and the implementation of good practices retrieved from other museums. Fourth stage shows that the integration and the interoperability of digital platforms enabling virtual tours are based on common and shared standards within the museum. Fifth stage reflects a solid technology infrastructure, which fully supports digital experiences for museums' virtual visitors. These five scale points are also assigned to different qualitative anchors (Table 3).

Table 3 - Calibration of scales for the outcome

Scale point	Fuzzy-set value	Membership
Digital oriented	1	Fully in
Integrated and interoperable	0.75	More in than out
Defined	0.50	Cross-over (neither in nor out)
Partially planned and implemented	0.25	More out than in
Initial stage	0.05	Fully out

Source: adapted from Ragin, 2014

Based on the membership scores, sub-set relations related to digital transformation readiness can be analyzed whereby two aspects, the consistency and coverage are mainly analyzed (Ragin 2006).

Findings

Once the variables were calibrated, the second step contains the determination of the truth table. The fuzzy-set scores are used to construct a data matrix such as a truth table, which captures the opportunity to analyze different configurations of cases by highlighting all possible combinations of causal conditions and performing the analysis of sufficient conditions (Kraus et al., 2018; Pappas, and Woodside, 2021). Each case is considered as a configuration (in this peculiar context, a combination of the digital enablers, such as social media, AR, VR and AI chatbots). Five configurations were detected in the sample, 18 cases from 30 leading to the highest consistency – Table 4.

Table 4 - Truth table analysis

SM	AR	VR	AIPC	Number	DTRL	Raw consistency	Proportional reduction in consistency
1	1	1	1	18	1	0.9762	0.9586
1	1	1	0	4	1	0.9521	0.8482
1	0	1	0	1	1	0.9473	0.7371
1	0	0	0	2	1	0.8817	0.4429
0	0	0	0	1	1	0.8805	0.1927

Source: fsQCA software output

In the attempt of finding the complex solution, we have applied the consistency cut-off of 0.8, where the membership score of the outcome (digital transformation readiness level) is consistently higher than the membership score of the causal configurations related to the four digital enablers of museums' activities (social media, AR, VR and AI chatbots). The truth table is the precursor of the complex solutions, providing successful recipes for the outcome. The complex solution provided by the Quine-McCluskey algorithm outlines four configurations of antecedent conditions (~AR*~VR*~AIPC; SM*AR*VR; SM*~AR*~AIPC and SM*VR*~AIPC) leading to the outcome. Thus, fsQCA equifinality principle is validated. These combinations, even if some antecedent conditions have assigned low scores, are successful recipes for museums to achieve a higher digital transformation level in the Maturity Model. Moreover, the configuration (SM*AR*VR) reaching the highest consistency score (0.9532) reflects that social media, AR and VR technologies are the most influential predictors of the digital transformation of museums (Table 5).

Table 5 - Complex solution for the research model

Complex solution	**Raw coverage**	**Unique coverage**	**Consistency**
~AR*~VR*~AIPC	0.2983	0.00	0.8621
SM*AR*VR	0.8843	0.4149	0.9532
SM*~AR*~AIPC	0.3575	0.00	0.8812
SM*VR*~AIPC	0.4775	0.00	0.9375
Solution coverage: 0.8925			
Solution consistency: 0.9105			

Source: fsQCA software output

We found four necessary conditions (common conditions in sufficient configurations) using fsQCA specific function. The condition including all the four constructs (SM + AR + VR + AIPC) proved to achieve the maximum consistency score (0.9922) – Table 6.

Table 6 – Necessary conditions for the outcome (DTRL)

Conditions tested	Consistency	Coverage
SM + AR + VR + AIPC	0.9922	0.8441
SM + AR + VR	0.9879	0.8492
AR + VR + AIPC	0.9681	0.8803
SM + VR + AIPC	0.9884	0.8467

Source: fsQCA software output

The main conclusion of fsQCA analyses is that all four antecedent conditions—namely, high social media score, high and low AR score, high and low VR score, high and score pAI powered chatbots score —appear in all pathways and lead to high digital transformation readiness level. Furthermore, four simple antecedent conditions are necessary (though not sufficient) for high digital transformation readiness level.

Conclusions

Experimenting with the use of artificial intelligence in museums is in its infancy, but the results are promising. The existing partnerships between major museums and major players in the IT field, from universities to major developers (IBM, Microsoft, Facebook, Amazon, etc.) give us hope and are an excellent example of how AI offers the possibility of specialized staff. to make history and art more accessible and to connect the museum to a wider audience, with a degree of personalization of the content unprecedented until now.

The relevance of museums' use of AI tools for the community they belong to was realized especially during the restrictions imposed by the Covid-19 pandemic. The accessibility offered by AI has given the chance to museums that have implemented such programs to stay connected to their audience or even gain new visitors.

AI is a key discipline for many areas of activity, as it amplifies the development of new technologies, tools and innovative applications, but we must also mention that there is no set of "good practices" with universal applicability, but solutions well adapted to particular situations and a specific audience.

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