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AUGMENTED REALITY, SOCIAL CONSTRUCTS AND SUSTAINABILITY OF CULTURAL HERITAGE SITES

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ABSTRACT

The strategic foundation of Mexican cities at the beginning of the 16th century allowed economic administration and enabled mining facilities, as well as mineral transportation from inland territories to Veracruz port, and at the end of the crossings to the Port of Cadiz Bay, Spain, through maritime transportation. These circumstances were the seed of cultural values – in addition to Pre-Columbian civilizations – that detonated cities development, but also historic elements worth analysing in the present time, e.g. the Royal Mining Road. Afterward, industrialization processes became relevant to urban growth. Nowadays and during the last decade, the use of electronic devices and the cyberspace have allowed people enormous possibilities of interaction with unknown places. The increasing information on the internet permits several ways of organizing data so people can learn valuable facts about cultural heritage sites, such as buildings and industrial solutions to solve quotidian life challenges as details of human existence. Augmented reality is a tool that can improve understanding of cultural heritage sites. Web surfers can visit a museum and interact with objects and learning experiences. The main purpose of this paper is to analyse several points of views – in a diverse range of ages – to determine how we make social constructs of cultural heritage by augmented reality, but also to define if these tools can be of help for a sustainable city management, addressing the three major variables: environment, economy and especially society. The results of the questionnaires, based on a statistical method, helped us define the interpretation of the past becoming accurate with the use of augmented reality in museums and schools, but also conclude if people become more sensible about historic preservation through industrial archaeology facts and architectural evidences. The paper shows what happens in Mexico in order to illustrate general principles in Ibero-America.
Keywords: sustainable city, preservation, social constructs, heritage sites.

1 INTRODUCTION

Mexico is a fascinating country with Pre-Columbian and modern architecture. But also, it is a cultural melting pot, blending Indian traditions with nowadays skylines. The vibrant celebrations – mainly religious – are embedded in the whole country. These facts make possible culture preservation by collections of art and iconic historic artefacts, basically in museums. But the challenge is the use of current technologies to make the museums more attractive for visitors and Internet users.

The museums mentioned as examples in this paper exhibit works of art in different architectural spaces and distinct exhibition techniques. Three museums were selected to write this paper: The National Museum of Anthropology in Mexico, The Prado National Museum and San Isidro Sugar Mill Museum in Spain.

The National Museum of Anthropology was built in Mexico City from 1963 to 1964. Pedro Ramírez Vázquez designed it to show the diverse Pre-Columbian cultures and heritage sites in one place. The museum became quickly one of the most important museums of Mexico and it was fully completed for the Olympic Games that took place in 1968 in Mexico. Recently its website included an augmented reality tour, especially for the Mixteca culture hall. The Aztec empire was part of this culture. Good architects build good architecture, and the museum is a masterpiece. Ramírez Vázquez knew the importance of designing such building that he expressed correctly what the government and the society needed during those days. The main squared 'patio' became a centrality that distributed the entrances to every

culture exposed (see Fig. 1). But also – in terms of aesthetics – the façades of the main 'patio' are covered with fixed shutters, but using shapes of the Pre-Columbian world, like the monks quadrangle of Uxmal. This is a modern and a genius solution to show that antique architecture can reveal its presence nowadays. Also, Ramírez Vázquez included a big umbrella made of concrete and steel to protect the visitors against the sun light and rainwater. The main column of such umbrella has a foundation with 44 pilots from the subsoil – with less organic material – to the main museum soil level. In fact, the historic centre of Mexico City has muddy ground because of Texcoco Lake, indeed the main settlement of the Aztec Empire was on this lake. Günce and Misirlisoy mention 'In a museum, aspects like organization of displays, circulation or lighting in a museum are important aspects for a successful exhibition design. Additionally, when a museum is in an architectural heritage, this situation may create more challenges both for designers and museographers since important concerns for conservation and museography should be taken into consideration together' [1]. The bureau in charge to protect and preserve the historic heritage in Mexico is the National Institute of Anthropology and History (INAH). It includes archaeological, anthropological and historical heritage. In fact, the INAH bureau administrates one of the museums analysed in this paper: Also, the INAH encourages research and explores archaeological sites. According to information obtained from the bureau in Mexico, 28,000 archaeological sites have been discovered, but only two hundred are open to visitors. The INAH is a noble organization, but also requires a subvention increment to operate adequately and to fulfil the needs of taking care of the enormous heritage of Mexico. But innovations like the use of augmented reality in certain museums are in fact a set of opportunities.

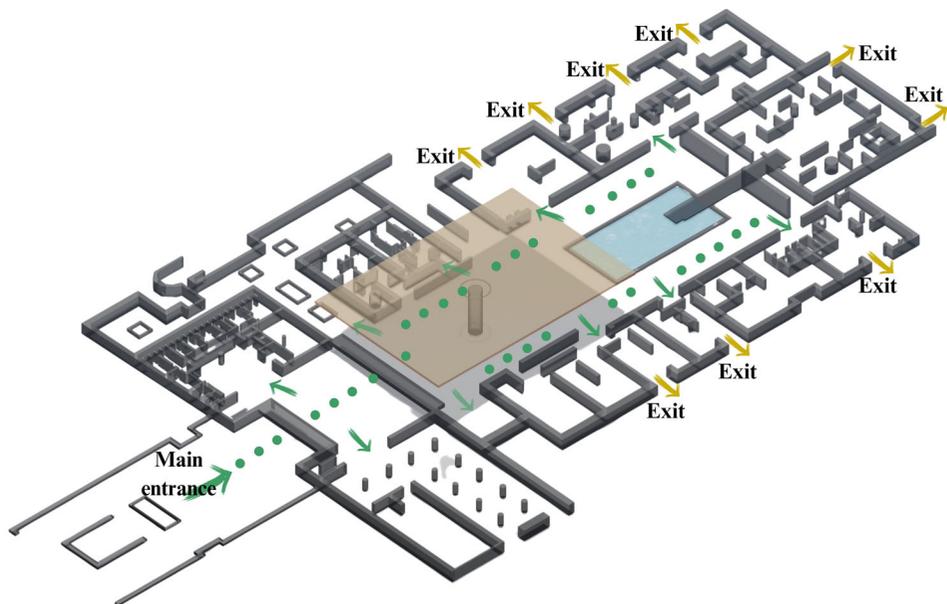
Figure 1:   The main squared 'patio' became a centrality that distributed the entrances to every exhibition area (Pre-Columbian cultures and heritage sites). *(Source: Drawing made by Alejandro Acosta Collazo and Anette Liliana Hernández Díaz.)*

The Prado Museum is the most visited in Spain with more than three million tourists per year. No wonder they proposed high technology to encourage people to visit the museum, even though it is by augmented reality or virtual tours. Juan de Villanueva originally designed the building in 1785. Also, Rafael Moneo designed new spaces to complement the needs of the original building in 2007. Observing the architecture in site is a good experience, as well as the works of art, but using augmented reality, visitors can learn at any moment about the extraordinary painting exhibited in site.

The idea of selecting San Isidro Sugar Mill Museum in Spain came over after working in the field of industrial heritage for several years, even though the concept 'industrial heritage' is relatively new, but no less essential. Also, Spain is a worldwide leader in the development of research and preservation of industrial heritage, so museums play an important role, also in education by creating awareness about cultural values. Definitely, new projects like San Isidro Sugar Mill enhance the recognition of industrial heritage.

2 AUGMENTED REALITY AND MUSEUMS

In accordance with National Geographic® Batlle Cardona mentions the 12 most important museums in virtual modus: 1. Hermitage Museum in Saint Petersburg, 2. El Prado Museum in Madrid, 3. Uffizi Gallery in Florence, 4. The Louvre Museum in Paris, 5. The Museum of Modern Art in New York City, 6. The Vatican museums, 7. The British Museum, 8. D'Orsay Museum in Paris, 9. The National Museum of Anthropology in Mexico City, 10. São Paulo Art Museum, 11. National Museum of Modern and Contemporary Art in South Korea and 12. Van Gogh Museum in Amsterdam. During the writing of this paper, only two among the list were selected as samples to be examined: El Prado Museum in Madrid and The National Museum of Anthropology in Mexico City besides the San Isidro Sugar Mill Museum.

Museums are relevant for societies and are linked with their identity. Günçe and Mısırlısoy say heritage buildings provide a valuable notice of the past and give character to communities and therefore be conserved for future generations [2]. So, preservation of culture has not only to do with works of art, but with the whole museum as a container of art.

Moreover, when referring to historical narrations, Gerome de Groot says: The historical text is constantly calling attention to itself as a construct but the reader happily forgets this [3]. Museographers try to represent the reality on a very accurate way but this is a complicated matter to achieve. Indeed, imaginaries always take place. Furthermore, education aspects happen in good exhibitions. Also, de Groot mentions that an historical novel is one step more complex than a contemporary novel because of its historical quality [4]. In professional exhibitions the more historical quality takes place, the better it is.

A good option for museums nowadays is the use of new technologies to exhibit and explain works of art. The use of video recordings helps to understand details of what is been exposed and understand and learn from experiences abroad or from some other geographic places. Augmented reality (AR) is a technology that enhances the real-world environment around us by overlaying computer-generated content onto it [5]. The use of such technology in the making of movies nowadays is very common.

AR and virtual reality (VR) gained important attention during the last decade and afterward, especially from 2011 to 2022. We can divide this period into two parts: each period includes 6 years. The first part includes years 2011–2016 where AR and VR in education were growing slightly [6]. In education, AR is more widespread with the idea of improving all its levels. Parveau says AR is conventionally defined as a technology that allows the superimposition of virtual information upon the real world, for example, by adding text or an image to what the user sees [7]. But how this technology can really match real situation

without using superfluous imaginary past situations and without losing reality aspects is a challenge. Abdallah et. al. mentions that AR technology has transformed how users engage with digital content within real-world environments, yet ensuring a high-quality AR experience remains a complex challenge due to the multitude of factors affecting user perception and satisfaction [8]. This is one of the reasons social constructs impact the way AR successes inside a changing world and rapid development of high quality technologies.

3 METHODOLOGY

A multifactorial statistical method was used to solve the qualitative evidences; in fact, a multiple correspondence analysis (MCA) was applied, specifically a Burt's matrix. The items included in the questionnaire related to the National Museum of Anthropology were: 1. Age group: young (13–17 years), adult (18–60) and senior (60+). 2. Gender: male or female. 3. Educational level: basic studies (primary, secondary, high school), undergraduate (bachelor's degree) or post-graduate. 4. Origin: Mexican or foreigner. 5. Why do you consider it is important to understand the Mesoamerican culture today? Artistic and cultural values or cultural identity. 6. Observing the 'Stone of the Sun' during the virtual tour, based on your interpretation. What does it represent to you? Aztec calendar, object of study and global recognition or artistic and technical value. 7. By interacting through this augmented reality experience; did you understand why this archaeological vestige is important to society? (Explain…). 8. What does the general interpretation of this room remind you of (or mean to you)? cultural progress, decline of civilisations or historical legacy. 9. After observing the replica of Moctezuma's headdress during the virtual tour: What is your opinion regarding the fact that such an important piece is not in its country of origin? Historical relevance or cultural regression. 10. What did you enjoy most about the tour and why? (Explain…). 11. Do you consider this virtual tour helps you to understand heritage? (Explain…). 12. What elements would you implement to make the virtual tour experience more engaging? (Explain…).

The second questionnaire was about El Prado Museum, situated in Madrid. The items were: 1. Age group: young (13–17 years), adult (18–60) or senior (60+) 2. Gender: male or female. Educational level: basic studies (primary, secondary, high school), undergraduate (bachelor's degree) or post-graduate. 4. Origin: Mexican or foreigner. 5. Do you think it is important to understand art and social transformations? It prompts us to question cultural identity, in order to interpret it or change it, it reflects collective emotions or it encourages the development of critical thinking. 6. When observing the painting: *'Work, Rest, Family'* by Enrique Martínez Cubells *(Room: Work in the Field)* during the tour, do you think you can learn something about working life of olden days? A comprehensive view of human life, the culture of labour in society or a way of living conditions. 7. Do you believe that 'collective thinking' influence your own behaviour? Yes or No. 8. By interacting through this augmented reality experience, can we consider the period 1885–1910 as a transitional stage towards modernity? Yes, it shows progress or to some extent there is still repression. 9. Through this augmented reality interaction, did you understand how the emergence of the labour movement and trade unions had an impact? Improvement of working conditions, class-consciousness and organization or the shaping of a new social culture. 10. What did you enjoy the most about the tour, and why? (Explain…).

The third museum chosen to be included in this paper was San Isidro Sugar Mill Museum in Spain. The fact of promoting preservation of industrial heritage and the use of augmented reality were the main selection reasons. A special questionnaire was made with the following items: 1. Age group: young (13–17 years), adult (18–60) or senior (60+) 2. Gender: male or female. Educational level: basic studies (primary, secondary, high school), undergraduate (bachelor's degree) or post-graduate. 4. Origin: Mexican or foreigner. 5.What can visitors

learn during the tour of the sugar factory? Industrial history and its connection to Granada society, life in the medieval era or how traditional sweets are made? 6. What role did the San Isidro Sugar Factory play in the development of Granada during the 20th century? Economic transformation, industrial transformation, or: For the promotion of improvements in communications. 7. The complex was acquired by the University of Granada. What do you believe this step means for the future of the building? Deterioration, opportunities or integration. 8. How can a place for research and innovation reinterpret its industrial past? Through historical-urban study, by the type of use given to the site or by recreating its original facilities. 9. What type of heritage does the San Isidro sugar mill represent? Asset of cultural interest (BIC), world heritage site or historical monument. 10. What did you enjoy the most about the tour, and why? (Explain). 11. Do you consider that this virtual tour helps you understand and appreciate cultural heritage? Yes or No. 12. What elements would you implement to make the experience of this augmented reality more engaging? (Explain…).

4 RESULTS

The main results of the qualitative questionnaires applied for the making of this paper are demonstrated in Figs 2, 3 and 4. The questions and answers selected as a synthesis of precise results are related to selected informants who dedicated more time to answer accurately.

Qualitative questionnaires results		
Museum:	Question:	Synthesis of precise results: (informants)
National Museum of Anthropology	7.- Why this archaeological relic is important to society? (Explain).	1. "knowledge about human behaviour".
		6. "Appreciate what our ancestors left behind".
		10. "Understanding of their worldview and daily life".
		12. "How this element has influenced Mexica culture".
		13. "History and context of ancient relics".
	10.- What did you like most about the tour and why? (Explain).	1. The scale of what the city of Tenochtitlan was and its visual representation. –Basic studies (primary, secondary school, sixth form)/Adult (18-60) years old.
		3. The interaction with the objects and being able to move freely around the room –Undergraduate (degree)/Adult (18-60) years old.
		4. The images are in excellent clarity – Undergraduate (degree)/Adult (18-60) years old.
		5. Being able to go somewhere I hadn't seen in a while and also the visual quality –Undergraduate (degree)/Adult (18-60) years old.
		10. That it addresses all the related topics in a very specific way, and that it highlights the physical heritage with real and concise information –Undergraduate degree/Adult (18-60) years old.
		12. The remote interaction –Undergraduate degree)/Adult (18-60) years old.
		13. They let you admire the detail and along with the explanation and the history behind them, it becomes even more interesting –Undergraduate degree)/Adult (18-60) years old.
	12. What element(s) would you implement to make the virtual tour experience more engaging? (Explain).	1. Using virtual reality headsets for the tour is generally appealing to the public –Basic studies (primary, secondary school, sixth form)/Adult (18-60) years old.
		3. Other rooms besides this one -Undergraduate (degree)/Adult (18-60) years old.
		4. A background melody appropriate to what is being displayed –Undergraduate degree)/Adult (18-60) years old.
		5. Recordings of explanations of the exhibits to help people understand things they were not familiar with or even to remember, and with fun facts that make the experience more entertaining –Undergraduate degree/Adult (18-60) years old.
		13. Create a kind of explanatory montage. A very noticeable animation is not necessary; it would just be a nice touch if you could grasp it better with that visual support –Undergraduate (degree)/Adult (18-60) years old.

Figure 2:   The main results of the qualitative questionnaires applied for the case of the National Museum of Anthropology, the open questions number 7, 10 and 12 show dynamic results of interpretation. *(Source: Figure made by Alejandro Acosta Collazo and Valeria Díaz Robles.)*

Qualitative questionnaires results		
Museum:	Question:	Synthesis of precise results: (informants)
The National Prado Museum	10. What did you enjoy the most about the tour, and why? (Explain).	1. The way art reflects the social struggle and living conditions of the time; it humanises history. –Undergraduate (bachelor's degree)/Young (13-17 years old).
		15. I learned about the historical context that was experienced at the end of the 19th century thanks to the works of art –Undergraduate (bachelor's degree)/Young (13-17 years old).
		19. I liked that the tour allowed me to focus on the details of the painting as well as the descriptions of each painting –Undergraduate (bachelor's degree)/Adult (18-60 years old).
		37. The sculptures –Basic studies (primary, secondary school, sixth form/college)/Adult (18-60 years old).
		40. The rooms are organised to help you understand which period they are talking about, so it is interesting to see the development through stages, understanding how everything was gradually changing –Undergraduate (bachelor's degree)/Adult (18-60 years old).
		47. I liked that it also offered the option of a recorded tour and explained the exhibition –Undergraduate (bachelor's degree)/Adult (18-60 years old).

Figure 3:   The main results of the qualitative questionnaires applied for the case of El Prado Museum, the open question number 10 shows preferences in the interpretation of architecture and works of art. *(Source: Figure made by Alejandro Acosta Collazo and Valeria Díaz Robles.)*

The results in synthesis of the qualitative questions of the National Museum of Anthropology: 7. Why this archaeological relic is important to society? It is important to pass on knowledge about behaviour throughout human history; It is a good alternative for people who want to learn about cultural and artistic values from a distance; Keeping in mind where we have been in the past guides us and reminds us where we are going or where we can go; It helps us appreciate the worldview and daily life of our ancestors. 10. What did you enjoy most about the tour and why? The handling of the journey, the interaction with objects, being able to go to places unknown, and the visual quality; It addresses all related topics in a very timely manner and highlights the physical heritage with real and concise information; To learn more about our culture, it is important to understand how ancient civilizations functioned; Seeing the high-quality replica of Moctezuma's headdress – I had never had the opportunity to do so before. 11. Do you consider that this virtual tour helps you to understand and appreciate heritage? Yes, because not all of us have the time or opportunity to visit them in person; Yes, because it allows you to see something even if you cannot be there physically, and thus observe new things or remember others; Yes, because it shows in a very interactive way what the past was like in our territory, and it allows us to see and understand how it has changed; Sure, it is a good way to learn about history, a kind of alternative to virtual books and articles. 12. What element(s) would you implement to make the virtual tour experience more engaging? Recordings of explanations of the exhibits so that visitors can understand things they did not know about or even remember them, with interesting facts that make the experience more entertaining; Background music that matches what is being shown; Other rooms apart from this one; Make some kind of explanatory montage. It doesn't need to be a much elaborated animation; just something that helps you understand it better with that visual aid would be a nice touch. The synthesis of precise results can be observed in Fig. 2.

Qualitative questionnaires results		
Museum:	**Question:**	**Synthesis of precise results: (informants)**
San Isidro Sugar Mill Museum	**10. What did you enjoy the most about the tour, and why? (Explain).**	2. The combination of history and industrial architecture. I found it interesting how a working-class space can now become a cultural and educational meeting place – (Undergraduate (degree)/Adult (18-60) years old.
		5. I liked observing how the original structure of the building has been preserved. It reflects the power of industrial heritage and how it can adapt to new uses without losing its essence –Undergraduate (degree)/Adult (18-60)
		18. The area where the models and three-dimensional recreations of the old buildings are located –Undergraduate (degree)/Adult (18-60) years old.
		19. The photos of the things they used, which were preserved as they were left for the last time –Undergraduate (degree)/Adult (18-60) years old.
		31. I liked how the strength of the industrial heritage is reflected –Undergraduate (degree)/Senior (+60) years old.
		33. I liked the way history was combined with technology because it makes the tour more interesting and easier to understand –Undergraduate (degree)/Adult (18-60) years old.
		36. It allowed me to experience the tour almost as if I were there in real life –Undergraduate (degree)/Adult (18-60) years old.
		41. I liked the way you can manipulate the tour and how the 360 images help people to understand the space. The zoom function also helps you understand what is in each area –Undergraduate (degree)/Adult (18-60) years old.
	12. What element(s) would you implement to make the experience of this augmented reality more engaging? (Explain).	2. Include audio with testimonies from former workers, 3D recreations of the machines in operation, and interactive maps with key points of the tour – Undergraduate (degree)/Adult (18-60) years old.
		5. I would implement immersive tours with virtual reality, period-appropriate ambient sound, and interactive avatars that explain the production processes –Undergraduate (degree)/Adult (18-60) years old.
		14. I would add sounds, short videos, and virtual guides –Undergraduate (degree)/Adult (18-60) years old.
		33. Include ambient sounds and testimonies from former workers to make the experience more immersive –Undergraduate (degree)/Adult (18-60) years old.
		41. Videos, audios, small explanatory texts, games, or facts –Undergraduate (degree)/Adult (18-60) years old.
		43. Perhaps videos that also explains the tour or the topic being presented –Basic studies (primary, secondary school, sixth form)/Adult (18-60) years old.

Figure 4:   The open questions number 10 and 12, in the case of San Isidro Sugar Mill show experiences and preferences in the interpretation of architecture and works of art. *(Source: Figure made by Alejandro Acosta Collazo and Valeria Díaz Robles.)*

The results in synthesis of the qualitative questions of El Prado Museum are: 10. What did you enjoy the most about the tour, and why? The way art reflects social struggle and the living conditions of the time; I liked how the tour allowed us to focus on the details of the painting as well as the narratives of each painting; It was interesting to see the development in stages, understanding how living conditions gradually changed; I liked that the tour offered a guided tour option explaining the exhibition. 12. What element(s) would you implement to make the virtual tour experience more engaging? I would improve access to the routes; Educational texts, sounds and interactive images. Also, it is convenient to add a user-friendlier interface to attract younger audiences to these virtual experiences. The synthesis of precise results can be observed in Fig. 3.

The results in synthesis of the qualitative questions of the San Isidro Sugar Mill are: 10. What did you enjoy the most about the tour, and why? This method of touring is very interesting; A very interesting experience that helps you gain more knowledge; I like the way you combine history with technology. It makes the tour easier to understand; It allowed me to experience the journey almost as if I were there; I liked the way you can manipulate the touring experience. 11. Do you consider that this virtual tour helps you to understand and appreciate cultural heritage? Knowing its history and significance helps you to appreciate and value the place; It clearly shows the historical and social value of the place, allowing us to imagine its former function and future potential without being physically there; It forces you to concentrate fully on the content, facilitating overall understanding of things as you go along the tour; Offers immersive experiences in the place shown, helping to be interactive by generating greater interest. 12. What element(s) would you implement to make the experience of this augmented reality more engaging? More videos, audio files, short explanatory texts, games, facts or ambient sounds. The synthesis of precise results can be observed in Fig. 4.

5 DISCUSSION

In addition to the last section, a discussion is included to identify the main differences and research outcomes from the qualitative questionnaires (Figs 2, 3 and 4) and the quantitative questionnaires (Figs 5, 6 and 7). Basically, the questioned people are Mexican; the virtual visitors are interested in art and social transformations; people recognize the power of virtual

Quantitative questionnaires results			
Museum:	**Question:**	**%:**	**Synthesis of results:**
National Museum of Anthropology	**Age:**	100%	Of respondents were adults (18-60) years old.
	Gender:	50%	Of respondents were men.
		50%	Were women.
	Studies:	70%	Of respondents have bachelor's degree.
		20%	Have basic studies.
		10%	Have a post-graduate degree.
	Nationality:	100%	Of respondents are Mexican.
	Mesoamerican culture today:	60%	Of respondents consider it important for its artistic and cultural value.
		40%	Consider it a cultural identity.
	Stone of the sun meaning:	60%	Of respondents consider it important for its artistic and cultural value.
		40%	Consider it a cultural identity.
	General interpretation:	50%	Of respondents consider it an object of study and worldwide recognition.
		30%	See it as the Aztec calendar.
		20%	See it as an artistic object of technical value to culture.
	Moctezuma's headdress interpretation:	60%	Of respondents see it as historically important.
		40%	See it as a cultural regression.

Figure 5:   Results in synthesis of the quantitative questions of the National Museum of Anthropology. *(Source: Figure made by Alejandro Acosta Collazo and Valeria Díaz Robles.)*

Quantitative questionnaires results			
Museum:	**Question:**	**%:**	**Synthesis of results:**
The National Prado Museum	Age:	78%	Of respondents were adults (18-60) years old.
		11%	Were young (13-17) years old.
		11%	Were seniors (+60) years old.
	Gender:	72%	Of respondents were men.
		28%	Were women.
	Studies:	83%	Of respondents have a bachelor's degree.
		17%	Have basic studies.
	Nationality:	94%	Of respondents are Mexican.
		6%	Are foreigner.
	Importance of art and social transformations:	72%	Of respondents believe that it helps us to question cultural identity, interpret it and transform it.
		22%	Thinks that is a collective reflection of emotions.
		6%	Believe that it encourages the development of critical thinking.
	Interpretation of "Work, Rest, Family" by Enrique Martínez Cubells paint:	55%	Of respondents believe that it reflects the work culture in society.
		28%	Think that represents the comprehensive vision of human life.
		17%	Believe that it reflects the living conditions.
	"Collective thinking" influences your own behaviour?	89%	Of respondents agree.
		12%	Thinks the opposite.
	Can we consider the period 1885 –1910 as a transitional stage towards modernity?	78%	Of respondents believe that it shows progress.
		22%	Think that it shows moderate progress.
	How the emergence of the labour movement and trade unions had an impact?	50%	Of respondents consider it was trough the development of working conditions.
		39%	Believe it was through class-consciousness and organization.
		11%	Think it was through the creation of a new social culture.
	This virtual tour helps you to understand and appreciate artistic expression and cultural capital?	100%	Of respondents agree.

Figure 6:   Results in synthesis of the quantitative questions of the National Prado Museum. *(Source: Figure made by Alejandro Acosta Collazo and Valeria Díaz Robles.)*

reality. Also, the use of graphics in museums contributes to increased interest in works of art and preservation of heritage sites. Furthermore, most of the people recognize that collective thinking influences their own behaviour. This is why narration of accurate history becomes crucial on establishing people's credibility. Another advantage of using augmented reality is that knowledge becomes closer to everyone, without traveling to visit museums.

As a consequence of the analysis of the results, a semantic map was drawn to demonstrate how people perceived cultural heritage sites. Human and augmented reality is a good issue to be studied nowadays because of advances of recent technologies. Real world is 'using' hardware filters – like computers and electronic devices – to abstract realities in museums. Such process becomes a digital interaction (see Fig. 8) by using AR and to create virtual tours. The will of the human beings becomes fascinated by these experiences and builds social constructs, like focusing on details; understanding changes from the past to nowadays;

Quantitative questionnaires results			
Museum:	**Question:**	**%:**	**Synthesis of results:**
San Isidro Sugar Mill Museum	**Age:**	87%	Of respondents were adults (18-60) years old.
		13%	Were seniors (+60) years old.
	Gender:	60%	Were men.
		40%	Were women.
	Studies:	87%	Of respondents have bachelor's degree.
		13%	Have basic studies.
	Nationality:	100%	Of respondents are Mexican.
	Main idea about the sugar mill:	93%	Of respondents interpret the main theme to be industrial and has a connection to Granada society.
		7%	Interpret it as how traditional sweets are made.
	San Isidro Sugar Mill role:	87%	Of respondents identified it as an industrial transformation.
		13%	Interpreted it as an economic transformation.
	The future of the mill:	73%	Of respondents identify it as an opportunity.
		27%	See it as part of an integration of what really exists.
	Industrial past reinterpretation:	87%	Of respondents believe that it is due to its historical –urban study.
		13%	Believe that it is subject to the type of use given to the site.
	Type of heritage:	93%	Of respondents consider it to be Asset of Cultural Interest (BIC).
		7%	Consider it to be a historical monument.

Figure 7:   Results in synthesis of the quantitative questions of San Isidro Sugar Mill Museum. *(Source: Figure made by Alejandro Acosta Collazo and Valeria Díaz Robles.)*
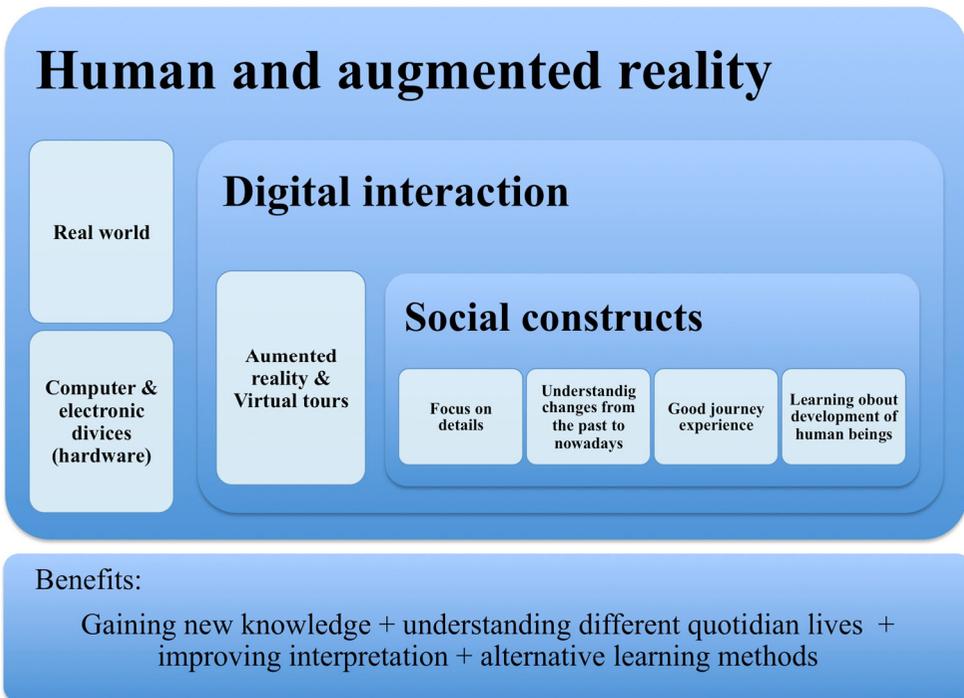

Figure 8:   Results of the social constructs about how people perceive cultural heritage sites. *(Source: Drawing made by Alejandro Acosta Collazo.)*

enjoying good journey experiences and learning about development of human beings. Indeed, good benefits can be acquired like: gaining new knowledge; understanding different quotidian lives; improving interpretation and exploring alternative learning methods.

6 CONCLUSIONS

Subsidy available to preserve the capital cultural exposed in museums is crucial nowadays. The three museums mentioned in this paper are so important for their own countries that the use of augmented reality is worth the investment. Indeed, they are valuable enough to justify high technology financing.

Technology in museums becomes an excellent tool to make people interact with learning experiences available worldwide. This is the case of storytelling in museums: the narration is a crucial tool for museums, as it allows visitors to relive historical experiences while also contributing to the definition of a society's common feeling, which they live in and integrate with [9].

There are also several technical advances that contribute to appreciation of works of art and architecture. In recent years disciplines like lighting have improved the ways of inhabiting the cities, but also in houses. The complexity of AR can be studied with multifactorial methodologies. But in the search of quality, accurate history plays an important role. Even though inequalities exist in Mexico, the government approved in 2025 more than 12 thousand and 81 million pesos for development of culture. The National Museum of Anthropology in Mexico is one of the most visited museums in Mexico with more than two million people per year.

Sustainability and cultural heritage can also be reached by citizenship education, but still more research is necessary to understand the correct tools for the sustainable city management and addressing the three major variables: environment, economy and society. Indeed, in the variable 'society', education and museums become relevant to increase identity in people. So, culture preservation is definitely associated with education and museums. In addition and concluding, the main variables detected of the major variable society, to reinforce cultural identity in museums include: Increasing interest in visitors to preserve valuable historical facts with AR; attracting young users of AR and VR to reinforce cultural identity; learning from history to be aware of what should be preserved; promoting democratic access to important museums through AR systems; integrating more people to the advantages of visiting museums by AR and learning from the past in order to avoid repeating the same mistakes again and again. So, this may be a path to promote principles of cultural sustainability, indeed the core of a sustainable city.

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