

One Exhibition for People in Two Places: An Analysis of the Visiting Behavior of Visitors of the Exploring IoT Special Exhibition in Taiwan and Macao

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ABSTRACT: This article takes the special exhibition «Exploring the Internet of Things» that will be moved to the Macao Science Museum in 2021 as an example, and conducts quantitative analysis through the «Online to Onsite visitor behavior system» built with the exhibition, and attempts to compare the same interactive multimedia display in this exhibition. Differences in audience satisfaction, visiting behavior and learning ability between the Macao Science Museum and the National Science and Technology Museum. The results show that there is no significant difference in the satisfaction of audiences with different cultural backgrounds for interactive installations, but the part of the visiting behavior that is comprehensively expressed in the National Science and Technology Museum. is «high-level participation», while Macao Science Museum, under the public's awareness of epidemic prevention, has reduced the level of participation. The willingness to interact only falls on the «middle-level participation». In the design of the display content and the presentation method of the display instructions, the Macao Science Museum has two units. The performance of the «correct rate» of answering or calculating questions is almost full, showing its excellent learning ability, indicating that it fully understands the scientific knowledge that this special exhibition intends to convey. With the characteristics of interactive multimedia display, the National Science and Technology Museum introduces information and communication technology, integrates the structure of the visiting behavior database into the exhibition, and proposes a virtual and real integration of intelligent museum display mode. The cloud-based online evaluation of «one exhibition, two audiences» verifies that this is a valuable combination of new thinking and practice in museology, which can be used as a reference for other museums to conduct overseas exhibitions in the future.

KEYWORDS: Museum exhibition, interactive exhibition, multimedia, oversea, Internet of Things.

1 INTRODUCTION

English science-fiction writer Arthur Charles Clarke once said, “Any sufficiently advanced technology is indistinguishable from magic.” Indeed, when the magic of technologies is applied to them, “objects” like refrigerators, tables, coffee machines, and scales will become “conscious” and “sensible.” This is the world created by the Internet of Things (IoT). Technological developments are advancing at a speed similar to what is known as Moore's Law for the fact that we see fascinating new technologies being introduced almost every day. In response to this global phenomenon, National Science and Technology Museum (NSTM) organized the Exploring IoT Special Exhibition (the Exhibition), using a diversity of exhibition techniques to turn IoT from an abstract idea to a tangible exhibition where the public could experience it hands-on. In particular, NSTM established an online to onsite visitor behavior system (OOVBS) to keep track of visitors' behavior in a real time manner.

The Exhibition made extensive use of interactive multimedia to create highly interactive real-world experiences. It also took advantage of OOVBS to instantly extract visitors' information and behavior during their visits, including basic information, feedback, learning outcomes, and overall performance. Both of these practices allowed it to develop a new and integrated online to onsite approach of visiting museums. While the museum sector has made considerable achievements in studying visitors' behavior in ordinary exhibitions, there is a lack of research and exploration with regard to visitors' patterns in exhibitions using interactive multimedia. If any, most of these studies provide introductory or summarized reports about exhibits at best. There is even less discussion on how interactive multimedia exhibitions extensively using information

technology as a display medium overcome differences in overseas environments and cultural backgrounds of visitors when they are exhibited internationally [1]. Hence, this study takes the Exploring IoT special exhibition of NSTM for example to examine and compare the behavior and satisfaction of visitors in Taiwan and Macao toward the same exhibition.

2 FEATURES OF THE EXHIBITION

Despite the COVID-19 pandemic, NSTM managed to move the Exhibition to Macao Science Center (MSC) in November, 2021. In addition to nine interactive multimedia exhibits, it also introduced the OOVBS that it developed on its own to Macao. It meant that this cooperation not only allowed the two museums to make an exchange in terms of exhibitions but also gave them the opportunity of cross-museum and cross-regional data collection, so that they could understand how different visitors in Taiwan and Macao felt about and reacted to the same exhibition.

NSTM used information technology, mobile devices, and micro positioning to design the Exhibition, combining interactive multimedia units with OOVBS to tell “the story of IoT.” Visitors started to visit after downloading the app of the Exhibition. When they approached a particular interactive multimedia unit, the beacon would activate the app and generate a corresponding bar code or number series (collectively known as the code). Visitors then went to the physical interactive multimedia kiosk to have the code scanned to complete the pairing code process and start to experience and learn. The system recorded visitors’ visiting trajectories and learning statuses, allowing them to inquire about their interaction with the units and their learning effectiveness even after they left the Exhibition.

In summary, the Exhibition had two major features in terms of its design. One is that it used interactive multimedia to give visitors an insight into the technological developments of IoT. The other is that it connected each of the units using the Internet and established OOVBS to record visitors’ behavior when they were using and interacting with the units. Here are the descriptions of the two features.

2.1 INTERACTIVE MULTIMEDIA EXHIBITION

What interactive multimedia exhibitions attract visitors the most are the fact that they provide not only such sensory experiences as visual, hearing, and touch but also interactivity by allowing visitors to receive instant feedback through interactive installations and inspiring them to create [1]. Most people today understand an interactive multimedia exhibition as an exhibition that is mainly composed of interactive installations enabled by interactive technology and combined with other multimedia installations or productions such as animated videos. The use of interactive multimedia technology in museum exhibitions has quite a long history. Since the mid-80s or so, museums have been using interactive multimedia technology to develop a variety of interactive multimedia exhibitions [2]. With the advancement of computer audiovisual processing and the increasingly mature touchscreen, somatosensory, projection, RFID, and immersive technologies, interactive installations for specific themes and cultural relics and even interactive theaters have started to rise, changing not only the ways museums interpret cultural relics but also the ways visitors experience the contents of exhibitions [3]. Of the nine exhibits selected for the Exhibition in MSC, the most representative were Experiencing Smart Cars and Fun of Virtual Shopping - both of which used VR devices - as well as Understanding IoT Framework, which was produced with machine learning AI algorithms. The six other exhibits were enabled by Leap Motion, touchscreens, and other somatosensory devices (see Table 1).

2.2 OOVBS

Of the wide range of media that can be used for exhibitions, what role do interactive exhibitions play in museums? Unlike the previous practices of issuing questionnaires or tracking responses, NSTM specifically designed OOVBS for the Exhibition, using information technology, mobile devices, and micro positioning to construct visitors’ learning behavior and track their visiting trajectories, so as to analyze their perception, understanding, needs, and learning effectiveness during their visits to the Exhibition. With the user behavior collected, NSTM was able to examine what and how information was presented at each of the exhibits and how to make improvement, so as to realize the real-time conversation between visitors and museums [4].

The system was integrated into the interactive units of the Exhibition and was enabled by 73 micro positioning beacons and interactive program design. The four indicators of the Bitgood (1994) [5] behavioral observation scale were used to categorize visitors’ behavior into four categories, which were (1) The degree of reading: Has the visitor correctly answered questions related to the exhibited content; (2) The degree of involvement: How much time has the visitor spent at the exhibit unit; (3) The state of operation: Has the visitor correctly operated the exhibit unit to complete the mission; and (4) The content of discussion: Has the visitor shared his/her experience in the Exhibition on Facebook or other social media platforms (see Table 1). The four categories were turned into performance criteria and embedded in the software of the interactive units. Visitors

simply had to download the app of the Exhibition, pair identifiers, and activate the interactive units to be able to retrieve information and behavior of all visitors at a particular moment, including basic information, feedback, and overall performance of visiting behavior. The contents and objectives of the interactive units were written and designed based on the plan of the Exhibition. A three-level scale was designed for the behavioral indicators, with L3, L2, and L1 standing for high, medium, and low level of visiting behavior, respectively. The grading criteria of the level system also provided the software of the interactive units with nodes for determination.

Table 1. Descriptions of interactive units and OOVBS rubric for Exploring IoT Special Exhibition

Interactive Multimedia Unit	Unit Description	OOVBS Rubric	
		Evaluation Indicator	Performance Criteria
			Level / Grading
Binary Challenge	Interactive unit with touch screen	Involvement	The number of seconds spent in the interaction L1: 30 sec.; L2: 60 sec; L3: 90 sec
Maker of Network Cables	Interactive unit with physical DIY materials	Operation	Follow instructions to complete mission L1: Initiate unit; L2: Half-way through the mission; L3: Mission complete
Understanding IoT Framework	Interactive unit for operating flash cards using machine learning	Operation	Follow instructions to complete mission L1: Initiate unit; L2: Half-way through the mission; L3: Mission complete
Make Your Own Smartphone	Interactive unit using Leap Motion	Involvement	The number of seconds spent in the interaction L1: 30 sec.; L2: 60 sec; L3: 90 sec
IoT School	Interactive unit with touch screen	Reading	The number of correct answers L1: None of the answers are correct; L2: Half of the answers are correct; L3: All of the answers are correct.
Experiencing Smart Cars	Interactive unit for VR experiences	Operation	Follow instructions to complete mission L1: Initiate unit; L2: Half-way through the mission; L3: Mission complete
Cycling for Health	Interactive unit with somatosensory devices	Operation	Follow instructions to complete mission L1: Initiate unit; L2: Half-way through the mission; L3: Mission complete
Be A Logistician	Interactive unit with touch screen	Operation	Follow instructions to complete mission L1: Initiate unit; L2: Half-way through the mission; L3: Mission complete
Fun of Virtual Shopping	Interactive unit for VR experiences	Operation	Follow instructions to complete mission L1: Initiate unit; L2: Half-way through the mission; L3: Mission complete
		Discussion	Fill out basic information and share it on social media L1: Fill out basic information; L2: Fill out satisfaction scale; L3: Select the favorite unit and share it on social media

3 COMPARATIVE ANALYSIS OF THE BEHAVIOR OF VISITORS OF THE TWO MUSEUMS

Data is meaningless in itself. It makes sense only after it is analyzed. For many organizations, data collection more than often plays a passive role. It is not until a problem does occur that these organizations start to analyze data to identify the cause, rectify the problem, and design precaution to prevent it from happening again [6]. Aspiring to move from a passive status to an active position, the Exhibition used beacon technology and embedded nodes in the software of the interactive units, so as to extract data in an automated way and turn it into useful information. OOVBS automatically extracted the information and behavior of all visitors on every business day and generated EXCEL reports. The reports indicated the levels of the behavioral indicators of visitors during their visits to the Exhibition based on their login time. When the Exhibition took place in NSTM, there were eleven interactive multimedia units been recorded by the system.¹ When it was moved to MSC, the

Exhibition was downsized to ten units in consideration of the exhibition space.² In accordance with Table 1, the highest score of visiting behavior was 33 points for NSTM and 30 points for MSC. The following is the comparative analysis of the behavior of the visitors of the two museums.

The Exhibition collected a total of 14,960 entries of visitor information in NSTM from 2016 to 2017 and 533 entries in MSC from 2021 to 2022. Whether in NSTM or MSC, there were more female than male visitors. In terms of age group, most visitors were aged 10 and above and under 13. In terms of satisfaction, 98.4% of NSTM visitors and 91% of MSC visitors were satisfied with the Exhibition. In terms of overall performance of visiting behavior, NSTM visitors achieved “high level of involvement” while MSC visitors achieved “medium level of involvement.” With regard to the most popular interactive unit, Maker of Network Cables ranked the first in NSTM as 32.6% of the visitors opted for it as their favorite interactive unit. In MSC, IoT School was preferred with 34.4% of the visitors reporting that they liked it the most. The above statistics are shown in Table 2. As for their feedback on the Exhibition, a majority of the visitors of both museums held a positive attitude toward the Exhibition, which proved that the Exploring IoT special exhibition did serve an educational function.

Table 2. Basic information, satisfaction, and behavioral performance of visitors of the two museums

Variable	Item	NSTM (N=14,960)	MSC (N=533)
		Percentage (%)	
Gender	M	49.7	47.28
	F	50.3	52.72
Age	10 and above – under 13	25.1	60.41
	13 and above – under 16	3.7	6.94
	16 and above – under 19	5.9	4.88
	19 and above – under 25	20.9	5.44
	25 and above – under 35	21.9	11.26
	35 and above – under 45	19.8	8.44
	45 and above – under 55	2.1	2.63
	55 and above – under 65	0.5	0
Satisfaction	Very satisfied	57.2	63.0
	Satisfied	41.2	28.0
	Neutral	1.6	0.9
	Not satisfied	0	0
Exhibition unit I like the most		Maker of Network Cables (32.6)	IoT School (34.4)
Overall performance of visiting behavior		High level of involvement ³ (22.35 points)	Medium level of involvement ⁴ (15.20 points)

3.1 OVERALL ANALYSIS AND DISCUSSION

The analysis of the basic information shows that there were more female than male visitors, a result that is consistent with those of other studies on museum visitors [7], [8], [9], [10]. The analysis of age group shows that most visitors were elementary school students, proving that the two museums actively promoted popular science education among teenagers. The fact that nearly 90% of the visitors held a positive attitude toward the Exhibition demonstrates that interactive multimedia exhibitions can give a more satisfactory experience to visitors. When it comes to the overall performance of visiting behavior, both of the museums had medium level of involvement or above, indicating that visitors were all willing to interact with the exhibits to learn about their contents instead of simply pressing buttons or fiddling with the exhibits.

In terms of the visiting behavior of the four evaluation indicators, it was rather difficult to make a comparison for the fact that the number of units exhibited in the two museums was different. This study therefore explains the level of visiting behavior of the two museums only (see Table 3). Both of the museums had high level of involvement in reading and discussion with the average scores of 4.44 and 2.26 in NSTM and 3 and 2.74 in MSC. For overall performance, NSTM achieved high level of involvement with the average score of 4.30 while MSC achieved medium level of involvement with the average score of 3.82. The two museums showed the greatest difference in the indicator of operation. When the Exhibition was held in MSC, visitors showed reduced willingness to use the two exhibits that used VR devices due to the pandemic. A lot of the entries were marked

as 0 point, which meant that there was zero involvement. Such a situation was in stark contrast with that of NSTM (medium level of involvement with an average score of 11.35) and was the reason why MSC had only a low level of involvement with an average score of 5.66 for this indicator.

Table 3. Comparison of the four OOVBS indicators of visitor behavior between the two museums

OOVBS Evaluation Indicator	NSTM Visiting Behavior Level	MSC Visiting Behavior Level
Reading		
Involvement		
Operation		
Discussion		

3.2 THE DEMONSTRATION OF LEARNING CAPACITY THROUGH PISA

Two of the interactive multimedia units of the Exhibition were incorporated with elements of examinations during their design. One was IoT School, which rated visitors’ performance based on how many IoT-related questions they answered correctly. The other was Binary Challenge, which tested visitors’ understanding of binary in computing and rated visitors’ performance in continuous calculation. The two units were designed for the museums to take advantage of the Exhibition to see if visitors had basic understanding of new technologies and mathematical logic. The data provided by the back end of OOVBS revealed that MSC outperformed NSTM in these two particular units as the former registered average scores of 3 and 2.99, which were almost full grade points, and the latter registered average scores of 2.63 and 1.68. This study therefore uses the two units to examine the learning capacity of students in Taiwan and Macao.

First of all, it uses Program for International Student Assessment (PISA) to analyze the phenomenon observed. PISA is an international assessment coordinated by Organization for Economic Cooperation and Development (OECD) to measure the learning status of 15-year-old students around the world once every three years. The results are announced one year after an assessment. The system was first conducted in 2000, and its major domain of study rotates between reading, mathematical, and scientific literacy, so as to understand how well teenagers can make use of knowledge gained at school in everyday life and if they have basic abilities that meet the requirements of the future society [11]. Macao did rather well in the latest PISA 2018 for the fact that it ranked the third in reading, mathematical, and scientific literacy, and that it was one of the places with the lowest percentage of low-performing students in the three items. Taiwan ranked the sixteenth, fifth, and tenth for the three items, respectively. The PISA reports showed that there was a significant gap between the two regions in the ranks of reading and scientific literacy. Such results were reflective of the scores of the two unites earned by the two museums.

Secondly, given that PISA measures the performance of 15-year-old students, this study conducts a cross analysis of the performance of visitors aged 13 and above and under 16 in the two units. It finds that the 37 samples of MSC achieved 100% accuracy with an average score of 3. The 554 samples of NSTM achieved 90% accuracy in IoT School with an average score of 2.37 and 65.4% accuracy in Binary Challenge with an average score of 1.09. In general, based on the analyses above, it is obvious that the results of the two interactive multimedia units, which were incorporated with mathematical knowledge in their design to randomly examine local students’ learning effectiveness, are similar to PISA results, and that students in Macao exhibited better learning capacity than their counterparts in Taiwan.

4 CONCLUSION

Most domestic and international studies on museum visitors, especially those related to exhibitions, focus largely on the relations between visitors' backgrounds and exhibitions as well as visitors' motivation, satisfaction or degree of liking, and their perception of the service or management of exhibitions. It is worth noting that most of these studies use visitors of physical exhibitions or museums as research subjects. There is a lack of studies and discussion entirely focusing on digital or interactive multimedia exhibitions [1], not to mention travelling exhibitions. The Exhibition was unique for the fact that it was an interactive multimedia exhibition held both locally and overseas and that it used information and communications technology (ICT) to instantly collect visitors' visiting patterns, recognizing that visitors' bodily reactions were genuine and could not be faked. The practice allowed it to gain an insight into how satisfied visitors were with the exhibits and how "visitors" interacted with "exhibits" [12], so that it could understand visitors' visiting behavior and learning trajectories. Using technologies to collect data for the comparison of visiting behavior of visitors in different museums and different regions also helped save the cost of issuing questionnaires manually.

The biggest benefit of using interactive installations in museums is that it increases involvement and enhances learning effectiveness. The statistical analyses of the Exhibition also proved that visitors of both of the museums, despite having different cultural backgrounds, showed over 90% of satisfaction toward the interactive multimedia units. The application of interactive installations and multimedia devices not only meets the expectation of traditional museums of developing a more engaging way for exhibitions but also serves as a powerful tool to introduce contents of exhibitions to overseas visitors with different cultural backgrounds [1]. Museum visitor behavior refers to the continuum of purposeful actions of visitors in museum environments. It is a series of activities completed through the interactive action of "exhibiting — visiting" in a specific venue space. For a long time, due to information asymmetry in the interaction between exhibitors and visitors, the management of related activities is mostly driven by experiences or manual collection of questionnaires. However, the advancement of ICT has made it possible for museums to collect visitor information throughout their visits in a technological way and use big data analytics to conduct delicacy management in a scientific manner [13]. OOVBS, which was built into the Exhibition in both of the museums, duly performed such functions and revealed the one thing that curators want to know desperately: the interaction between people (visitors) and objects (exhibits). It is known through the results of OOVBS analyses that NSTM visitors achieved a high level of involvement in terms of the overall performance of their visiting behavior while MSC achieved a medium level of involvement. With regard to the design of exhibit contents and the presentation of exhibit instructions, MSC achieved almost full grade points in IoT School and Binary Challenge, showing that MSC visitors attentively interacted with the exhibits and understood the scientific knowledge that the Exhibition tried to convey.

This study takes the Exploration IoT Special Exhibition, which was held both locally in NSTM and overseas in MSC, for example to examine how interactive multimedia exhibitions deal with differences in overseas environments and cultural backgrounds of visitors when they are exhibited internationally. It also compares the satisfaction, visiting behavior, and learning capacity of visitors in Taiwan and Macau. Museum visitors are at the end of the museum communication chain, so their visiting experience and behavior are the most important indicators for the effectiveness of communication. Taking advantage of the features of interactive multimedia exhibitions, NSTM introduced technologies to collect visitors' visiting behavior. By implementing this new mode of exhibitions, NSTM successfully established its visitor database and evaluated visitors' visiting behavior and learning patterns using the collected data. The case of the Exploring IoT Special Exhibition proves that it is feasible to put this new way of thinking of museology into practice, and so it serves as a reference for other museums planning to hold exhibitions overseas.

REFERENCES

- [1] Shao-cyun Wu, A Study on Visitor Satisfaction When Interactive Multimedia Exhibitions of Museums Are Exhibited Overseas, *Museology Quarterly* [J], 2014,28 (4) : 93-120.
- [2] Besser, H. The Transformation of the Museum and the Way It's Perceived [M]. *The Wired Museum: Emerging Technology and Changing Paradigms*, Washington, D.C.: American Association of Museums.1997: 153-170.
- [3] Parry, R. Recoding the Museum: Digital Heritage and the Technologies of Change [M]. New York, NY: Routledge, 2007.
- [4] Yan-ming Lin, A Study of Effectiveness of Interactive Multimedia Display at the National Museum of Natural Science, Yulin: Graduate Institute of Visual Communication Design, National Yunlin University of Science and Technology, 2004.
- [5] Bitgood, S. Designing Effective Exhibits: Criteria for Success, Exhibit Design Approaches, and Research Strategies. *Visitor Behavior* [J].1994,9 (4), 4-15.
- [6] Siao-bing Jhang, An Introduction to a Smart Museum Solution, *Mechanical & Electrical Engineering Technology* [J], 2016, Z (1): 235-238.

- [7] Wen-ling Lin & Yong-neng Lin, A Study on Visitors' Motivation of Evening Hours at Taipei Fine Arts Museum, *Technology Museum Review* [J], 2008,12 (3): 5-23.
- [8] Yong-neng Lin, A Study on the Motivation of Visitors to the Taipei Fine Arts Museum, *Journal of Museum and Culture* [J], 2013,6: 167-189.
- [9] Shao-Chi Pai, The Study of Visitors' Art Lifestyles and Leisure Satisfaction: A Case Study in Taipei Fine Art Museum [D], Taipei City: National Taiwan Normal University, 2012.
- [10] Fiona Lee, A Visitor Study on Taipei Fine Arts Museum in 2006, *Journal of National Taiwan College of Arts* [J], 2007, (80): 1-27.
- [11] Hei-tong Lam, Perspectives on Learning among Macao High School Students: An Exploratory Study [D], Taipei: Graduate Institute of Education, National Taiwan Normal University, 2021.
- [12] Fang-yi Su, Online to Onsite: A Case Study of Visitor Behavior Based on Beacon Technology, *Journal of Museum and Culture* [J], 2018,15: 43-64.
- [13] Cing Chen, The Application of Big Data Analytics in Museum Settings - An Example from the Data Centre of the Shanghai Museum, *Science Education and Museums* [J], 2018,3: 188-199.