

Educational Exhibition System and the Application of APP on Museum Mobile Learning – National Palace Museum as an Example

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ABSTRACT

With the rapid development of technological media, especially in graphic-user-interface and mobile computing technology, museums can improve their exhibition forms and the interaction mechanism to enhance their service level in educational and research purposes. This study aimed to investigate the application of mobile computing technology on museum mobile exhibition system - National Palace Museum (NPM) as an example. Two systems were reviewed and analyzed in terms of their capability in the enhancement of learning performance. The first is U-Museum, which is an on-line production system currently operated by NPM. The other is Mobilizing Digital Museum, which is a prototype developed by a research laboratory in National Chengchi University, that provides NPM artifacts information to mobile users. This study also offers new directions for museum exhibition to better accomplish their educational and research missions by adopting this new exhibition form.

Keyword: Museum, Exhibition, Educational Exhibition System, APP, Mobile Learning

1. Motivation

With the rapid advance of technological media and ever-changing technology, it becomes an important trend for the worldwide museums to digitize and archive national cultural heritage in electronic databases for public retrieval through Internet [2,3,4]. Due to its long history, Chinese civilization has a very rich culture heritage. National Palace Museum in Taipei is world renown in archiving the treasure of Chinese civilization. Since 2001, NPM has been digitizing and archiving its precious collections. Through the Internet, most of its digital archive is available to public retrieval to accomplish its mission of dissemination and exchange of museum collections for educational, research, and commercial purposes. On the other hand, mobile computing devices, such as smart phone and tablet, which have sophisticated graphical user interfaces and offer a totally new platform for a much larger population

of mobile users. NPM are adopting this new technology to enhance its service level to mobile users. This study aimed to investigate the application of mobile computing technology on museum mobile exhibition system, National Palace Museum as an example. Two systems were reviewed and analyzed in terms of their capability in the enhancement of learning performance. The first is U-Museum, which is an on-line production system currently operated by NPM. The other is Mobilizing Digital Museum, which is a prototype developed by a research laboratory in National Chengchi University, that provides NPM artifacts information to mobile users. This study will reveal many new forms of museum exhibition, information retrieval as well as mobile learning. The new interaction mechanism provided by APP offering the viewers with totally different experiences in both virtual space and physical space may lead to a media revolution. Finally, the mission of a museum to promote its visibility and effective mobile learning becomes achievable. Since the latter half of the 20th century, humans' perception of physical space had changed due to the advance of technology. In recent years, we have been experiencing new challenges in the virtual space induced by the newly innovated information technology, graphical human-machine interface, and mobile communication. In the research on future social trend conducted by J.F. Coates, Inc., the researchers thought that "communication" and "computer" will be the leading factors to change museums in the future. Those factors and other high-tech development, such as electronic device, laser, videodisc, and digital TV etc., would definitely affect museums' exhibition techniques and daily operation (Han, P. T., 2000). Chinese civilization and history is long-standing and well-established and National Palace Museum is world renown for its collection of the essence of Chinese culture. Chang, S. H.(2012)mentioned that since 2001, NPM started a program to digitize and archive their precious cultural artifacts in both text (metadata) and image formats. This digital archive is open to general public to access through the Internet so that knowledge communication and exchange of cultural artifacts, educational promotion, and commercial added-value could be achieved.

In summary, we rely on the cooperation between museum and information technology (IT) experts to do a join research and development on the expansion of digital museum functionality in order to better integrate virtual and physical cultural artifacts and exhibitions. The subjects of this study are *U-Museum*, which is an on-line production system currently operated by National Palace Museum, and *Mobilizing Digital Museum*, which is a prototype developed by the Mobile Computing and Network Communications Laboratory in National Chengchi University. This study conducts a comparative study on both systems.

2. Related Issues

Digitizing national cultural assets by information technology, archiving them in electronic libraries, providing retrieval functions on computers and various applications, and communicating them by the Internet have become an important index of cultural and information power of every country. The National Palace Museum, which has digitized most of its archives, has devoted itself to create a ubiquitous service system, which can be accessed anytime and anywhere through a mobile device as well as mobile communication network (National Palace Museum, 2013). This museum created a demonstration park for super quality in ubiquitous mode so that exquisite artifacts can be easily available to the public.

Compared to the physical archives, the greater advantage of digital archives is that we can flexibly exploit them in different ways to present their contents to serve users. For example, all types of collections could be linked to form a certain context according to time, category or a certain event so that users could investigate them to achieve the goals of appreciation, education, or research.

2.1 Museum Exhibition and Mobile Learning

Contents of museum exhibition mainly includes exhibition space, exhibition theme and exhibition object. Mobile users could access digital content both inside and outside the exhibition site. The content of museum that can be benefited by mobile and interactive techniques are summarized in Table 1.

Table 1. Content of museum applicable for mobile and interactive techniques

Content	Description
Exhibition space	<ul style="list-style-type: none"> • Information related to space layout
Exhibition theme	<ul style="list-style-type: none"> • Exhibition overall planning – general description, detailed description and story line • Metadata related to exhibition theme
Exhibition object	<ul style="list-style-type: none"> • Introduction and presentation of individual exhibit • Metadata related to each exhibit

Source : Made by the researcher of this study

The benefits of mobile learning on digital museum include: (1) it could be done either virtually or physically, respectively; (2) it could be done in an integrated way in both virtual and physical space; (3) it is capable of distance learning; (4) it could be done in mobile; (5) it has dynamic interactive capability. Compared to e-learning, mobile learning of museum exhibition was more interactive, individualized, functional and convenient in disseminating information. Moreover, it could provide real-time information, allow real-time marking, as well as enable integrated virtual and physical learning environment. Moreover, exhibition space is usually very limited so that

exhibition room may be crowded and visiting time may be limited. Mobile digital museum could alleviate these problems.

To enhance the performance of educational and promotion mission of museum exhibition, Weiser (1991) pointed out that “the most profound technologies are those that disappear”. Therefore, a good way to achieve this goal is to embed computing ability into the environment and learners could access and use different tools to learn anytime. Peters (2007) mentioned that mobile learning is the extension of e-learning and proposed the idea of “just in time, just enough and just for me”. John Seely Brown (2010) brought up the idea of “The Power of Pull” in which he mentioned that there are answers on the Internet for most questions such that we didn’t need to accumulate knowledge and one could just pull the resources from the Internet as needed. He concluded that this would be the best way of learning. Yeonjeong Park (2011) proposed the process of “U-Learning” (ubiquitous learning) as shown in Fig. 1.

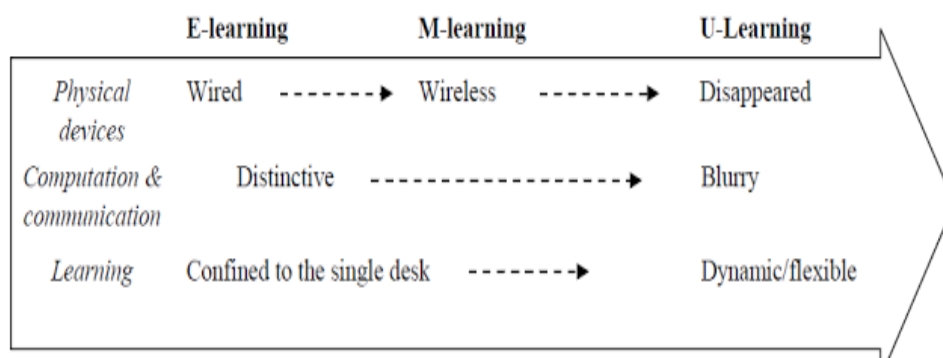


Fig. 1. Yeonjeong Park (2011) U-Learning (ubiquitous learning) development process

Source : Thesis of Yeonjeong Park, Virginia Tech, USA, 2011.

Yeonjeong Park (2011) pointed out that good learning design would produce benefits including: (1) more flexible cooperation; (2) obtaining learning feedback more rapidly; (3) obtaining community or other supports immediately in learning when needed; (4) more room for reflection; (5) building up authentic learning scenarios and challenges; (6) building up a location-based discovery process; (7) satisfying different learners’ preferences; (8) stimulating learners’ automatic learning in proper scenarios; (9) constant learning without time and space limit; (10) friends and family members could join in the learning process.

Song Y. T. *et al.* (2006) mentioned that the ultimate goal of museum mobile guiding is to assist museums to promote exhibition effects no matter what hardware and software combinations they have. In addition, the researchers of the study of Exploratorium (2001) pointed out that for the evaluation of electronic guidebook there were four issues to be addressed: (1) basic affordances; (2) attention to artifacts; (3)

paths through physical and virtual space; (4) higher effects, such as viewers' informal learning effects. Were they focused enough? How were their interactions with peers? What role did the guidebook play in these behaviors?

The study on the future trend of museum by Lin J. Y. and Yeh J. H. (2006) indicates that the viewing method would change from "static" method to "collection of multi senses". Viewers will view museum artifacts based on "event" or "action" and will have more interaction in exhibitions. Using human senses including hearing, vision, touching, smelling and memory feeling as the interactive media to create a multi-sensory virtual space will not only give viewer a more profound experience, but also enhance their educational and learning performance.

Mobile learning emphasizes "learner-centric learning". We propose the following framework for learner-centric learning specific for mobile digital museum as shown in Fig. 2.

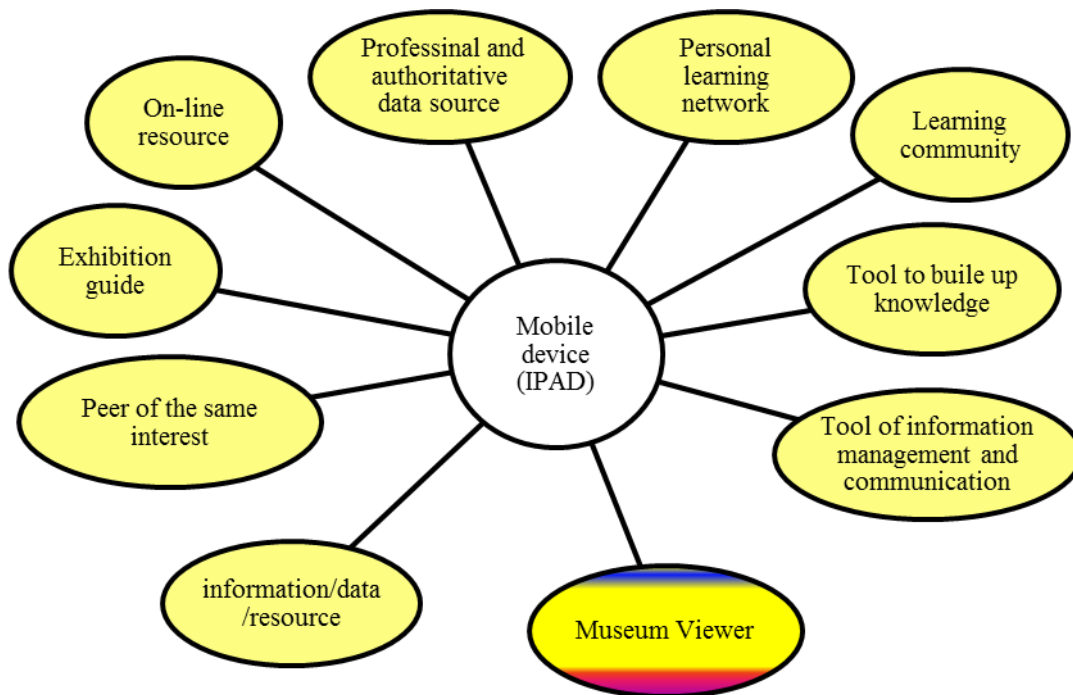


Fig. 2. Framework of leaner centric mobile learning for digital museum
 Source : Made by the researcher of this study

From the above discussion, it could be found that as the advance of information technology, the format and interface of presentation of museums has being evolved accordingly. On the viewer side, viewers are experiencing different presentation media and methods, thus are highly motivated on active learning and participation.

2.2 Analysis of Mobile Usage Environment – Related Problems and Solutions

In recent years, the development of mobile communication and cloud computing as well as the emergence of mobile devices such as tablet computer and smart phone have led to plenty of new information applications. According to the study of Lien Y. N., Jang H. C. *et al.* (2012), they pointed out that mobile device has intrinsic advantages and limits in the aspects of interaction ability, screen size, use model, communication bandwidth, and stability. In addition, mobile use model has its own special behavioral characteristics which are raised in a dynamic user environment such as (1) viewing time was generally very brief, (2) viewing windows must be enlarged, shrank or scrolled rapidly and conveniently, (3) easy to slide and click.

With a dramatic growth of service demand on the website operated by museums, its information equipment and network bandwidth couldn't be scaled up in a short time and therefore the service quality may be declined. Cloud service technology is a proper solution to alleviate this problem. The research team in National Chengchi University has being created a prototype of cloud based platform to provide audio and video streaming service offering some digital contents of NPM. Furthermore, the "Mobilizing Digital Museum" project is undergoing an experiment using P2P communication protocol to alleviate the problems raised by resource limits when the number of users dramatically increases.

In summary, mobile computing, cloud based service, P2P streaming, and mobile GUI (Graphical User Interface for mobile user), would impact all dimensions of APP design for mobile digital museum. The fundamental strategies we propose consist of four dimensions: BYOD (Bring Your Own Device), good mobile GUI design, using P2P communication protocol, and adopting cloud based services.

3. Comparative Case Study

3.1 U-Museum


According to the NPM website, the goals in educational and tour-guiding aspects of U-Museum indicated that (U Museum, 2009): (1) Establish the U-Museum knowledge infrastructure and become the 'educational model' for ubiquitous museums in Taiwan. (2) Establish a readily accessible U-knowledge network in Taiwan. Connect artifact IDs to the knowledge and sensory network, develop multi-themed National Palace Museum immersive digital contents, using multimedia and information communication technologies, in combination with ubiquitous interfaces and tools, to continuously expand the Museum's information and sensory network, thereby enabling the general public to more deeply explore contents regarding cultural artifacts and appreciate these artifacts. (3) Create a comprehensive U-Museum operating and promotion system with the "guided tour model": The

NPM’s evaluation and study of “U-Museum applications” will serve as valuable experiences for the U-Museum movement in Taiwan. Experiences can be shared with, and promoted to other international museums or countries undergoing the u-movement, thereby enhancing Taiwan’s international image and competitiveness. Establish an outstanding demonstration model of ubiquitous technology being used for personalized guided tours and UNS display centers in domestic museums or public spaces. Integrating ubiquitous technologies and interactive multi-media display systems (with ubiquitous human-display interactive mechanisms) in an UNS application environment to promote immersive appreciation of displays by visitors” (National Palace Museum, 2014).

3.2 NPM InSight App

National Palace Museum provided an APP for viewers to appreciate NPM exhibition using their own mobile devices. It offers excellent materials organized in eight categories: ceramics, jades, bronzes, curios, painting, calligraphy, rare books, and documents, two tour routes, personal bookmarks and interesting interactive games. The subsystems in the APP include: “Timeline”, which provides an overall survey of NPM’s collections organized by dynasty; “Permanent Exhibitions”, which provides two different guide modes including “Exhibition” and “Materials”; “Museum Tours”, which has two visiting routes including one 60-minute “Precious Collection” and one 90-minute “Splendid Heritage” so that visitors could save the time they may waste in fooling around inside the museum; “Interactive Games”, which offers some games such as “Treasure Hunt” Augmented Reality game and “Video Puzzle”.

Table 3. Description of “NPM InSight APP”

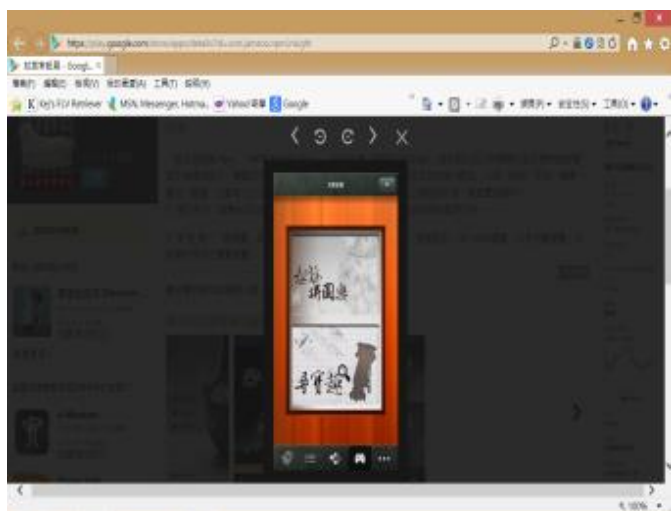
Subsystems	Description
<p>Timeline</p> 	<p>An overall survey of the NPM’s significant cultural artifacts in each historical period over thousands of years.</p>

Museum Tours

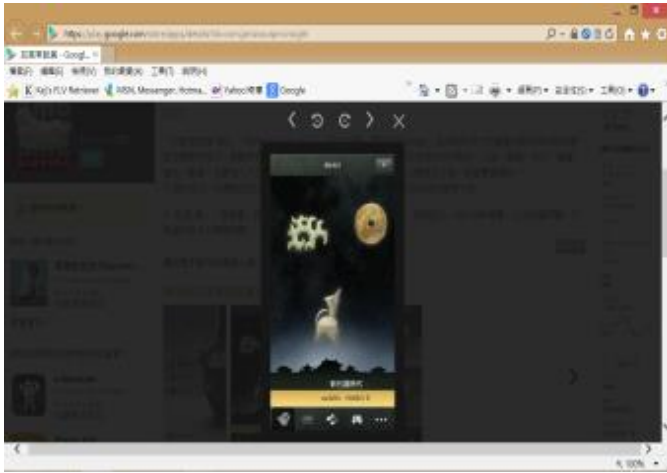


Visitors can set their own guide route. “More Info” contained information such as “Welcome to the NPM”, “Hours & Admission”, “Floor Plan” and users’ reviews. It also provides “Representative Cultural Artifact Guide” mode (suitable for general visitors) and “In-depth Guide Route Planning” and “Customized Adaptive Guide Route Planning” modes are suitable for visitors or scholars who have special viewing interests or research needs.

Interactive Games



“Treasure Hunt” and “Video Puzzle”.




<p>Visiting modes of “Exhibition” and “Materials”</p> 	<p>It offers guiding services including exhibition introduction, exhibition area location, QR code guide, multi-picture browsing, and pictures and metadata of artifacts, etc.</p>
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3.3 Mobilizing Digital Museum

Mobilizing Digital Museum is a project undergoing in Mobile Computing and Communication Laboratory, National Chengchi University. The name of the project properly implies their objective. They have designed and developed several prototype systems described in Table 2.

Table 2. Description of Mobilizing Digital Museum project

System Prototypes	Description
<p>Qingming Painting Graphical Exhibition System</p>	<p>Using hyperlinks to link all objects in the image of this painting to the backend metadata database. Users can touch an object (e.g. boat) on the image and then the metadata of the desired object will pop up from either the backend database or Internet. In this way, the digital “Along the River during the Qingming Festival” painting will no longer be just for viewing and will become an important tool for education and research.</p>

<p>Maogong Ding Inscription Graphical Exhibition System</p>		<p>Each character of the inscription of Maogong Ding is embedded with a hyperlink, and users who want to study Maogong Ding calligraphy can click on any character and then all calligraphy styles of the character including Zhuan, Li, and Kai as well as its evolvement will pop up. In addition to the web page, an iPad APP has been developed.</p>
<p>Maogong Ding Inscription Guessing Game System</p>		<p>This guessing game displays a character in Maogong Ding inscription as the question and several choices of Chinese characters in modern calligraphy, then asks user to pick up the correct answer. This edutainment system can simulate user's learning enthusiasm.</p>
<p>Navigation and user experience design</p>	 <p>The general layout of the product on Adobe Content Viewer, which is designed for free navigation to view the contents. Image courtesy of National Palace Museum.</p>	

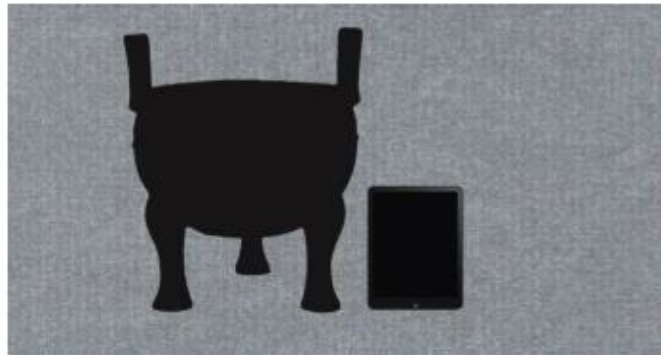
Exhibition on the iPad

Based on the web-flash version of the 3D Virtual Exhibition System, this product is to be redesigned to cope with the new form of interaction. The problem lies in how to exhibit the artifacts on a mobile device with touch screen.

The Structure of the Content 1



Panorama demonstration will be played automatically as user entering the page. Image courtesy of National Palace Museum.



Using recent popular tablet scale to give users the picture of how large the artifact really is. The device contains a 9.7 inches display.

The Structure of the Content 2



The Evolution of Chinese Characters, one of two interactive feature content for Maogong Ding.

<p>Realizing “Discourses to be Explored” with Interaction Design</p>	<div data-bbox="644 226 975 551" data-label="Image"> </div> <p>Utilizing touch screen, we designed a magnifier to view closely the detail of the jadeite. Image courtesy of National Palace Museum.</p>
<p>Tablet computer guide system of the artifacts of National Palace Museum</p>	<ul style="list-style-type: none"> ● Visitors bring their own devices (BYOD, Bring Your Own Device) and download the guide program before or after entering the site and then they can use the interfaces they're familiar with and start to use it, and this will solve the hygiene problem of a tablet guide commonly shared. ● Map interface allows users to search for artifacts conveniently by touch. ● 3D artifact viewing and interaction allow users to experience the effect of short-distance viewing, change viewing angles as they wish by touching the screen, and enlarge, shrink and rotate artifacts by finger sliding. ● It has written and verbal introduction of artifacts and multi-languages can be easily installed. ● iPad guide system of NPM also has the functions including viewing information related to artifacts outside NPM, guiding NPM's artifacts and planning visiting routes inside NPM, community interaction, and subscribing the latest news of NPM.
<p>Cloud and P2P streaming protocol for Guiding system support</p>	<p>Use cloud based system to store NPM's multimedia content and P2P streaming protocol to overcome the bandwidth limitation of mobile devices. Visitors can exchange each other's received multimedia data through wireless links such as Bluetooth and WiFi.</p>

3.4 Cloud Based U Exhibition Platform

The National Chengchi university research team led by Jang H. C. *et al.* (2012) constructed an U exhibition platform based on cloud architecture. The functionalities it offered are data management, xml-based data exchange, and push notification etc. The services it provided are exhibition floor plan, artifact browsing, special exhibition notification and general navigation. For the artifact browsing service, they used asynchronous picture download, intelligent artifact search, interactive 3D artifact model, and AR artifact techniques. Techniques employed by ubiquitous media exhibition platform is shown in Fig. 3.

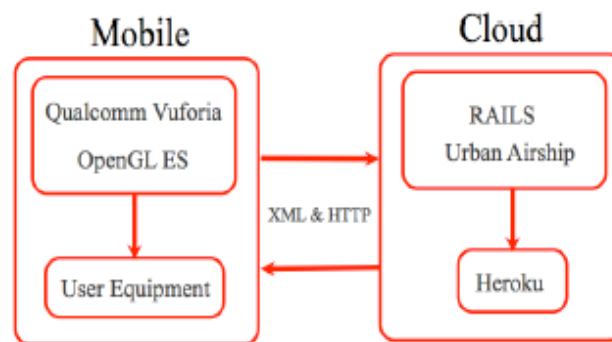


Fig. 3. Techniques employed by ubiquitous media exhibition platform

The above-mentioned cases are exactly the design that applied mobile computing, cloud based service, P2P streaming protocol, and mobile GUI technologies to accomplish an educational and entertaining presentation of NPM's cultural artifacts. In summary, with the advancement of information and communication technology nowadays an ideal APP should take into account mobile scenario, social networking, mobile learning and multimedia techniques and should present museum artifacts in a more diversified, convenient and richer manner.

4. Comparative Analysis

Our comparative analysis of the two systems described in Section 3 is shown in Table 4.

Table 4. Comparison of U-Museum and Mobilizing Digital Museum

Evaluation Metrics	U-Museum	Mobilizing Digital Museum
Basic Navigation Functions	<ul style="list-style-type: none"> • Human-computer interaction, multimedia exhibition, and mobile computing function. • Simplifying the interface of information presentation. • Applying tablet computers with multi-touch screen, allowing viewers to scroll images horizontally and vertically as well as zoom in and out by simple gestures. • Allowing viewers to see and read the metadata of exhibited artifacts through mobile devices. • With multi-languages capability. • As users click any artifacts on the screen, corresponding metadata will pop out. 	<ul style="list-style-type: none"> • Human-computer interaction, multimedia exhibition, and mobile computing function. • Simplifying the interface of information presentation. • Applying tablet computers with multi-touch screen, allowing viewers to scroll images horizontally and vertically as well as zoom in and out by simple gestures. • Allowing viewers to see and read the metadata of exhibited artifacts through mobile devices. • Having written and verbal introduction of artifacts and multi-languages can be easily installed. • As users click any artifacts on the screen, corresponding metadata will pop out.
Distribution of visitors attention	<ul style="list-style-type: none"> • Viewing artifacts information outside the museum. • Pushing the latest news to the subscribers. • Guided touring inside the museum. • Social network interaction. • 3D artifact viewing and interaction. • Lively, vivid and entertaining presentation. • Organizing artifacts according to the production time, users can choose their own starting point. 	<ul style="list-style-type: none"> • Viewing artifacts information outside the museum. • Pushing the latest news to the subscribers. • Guided touring inside the museum. • Social network interaction. • 3D artifact viewing and interaction. • Lively, vivid and entertaining presentation. • Flexible organization of artifacts (by production time, style, event, etc.)

Visiting Paths in physical & virtual space	<ul style="list-style-type: none"> • Real-time searching of literature related to the interested object on line. • Easy-to-read map interface. • Adaptive guiding route planning. 	<ul style="list-style-type: none"> • Using hyperlink technique to link all objects on the image of an artifact to the backend database or Internet. • Adaptive guiding route planning.
Higher level functions (such as multimedia data inquiry and browsing)	<ul style="list-style-type: none"> • Automatically updating the newest data through the server so that users' data will be updated at any time. • Adaptive to mobile scenario and integrated with social network, mobile learning and advanced multimedia technologies. • Discussing or experience sharing through social networking APP. • Sharing with others what a user is seeing by the video recording function on smart phones. 	<ul style="list-style-type: none"> • With P2P streaming protocol to share information among visitors to overcome the bottleneck problems raised by massive multimedia information dissemination. • Adaptive to mobile scenario and integrated with social network, mobile learning and advanced multimedia technologies. • Sharing with others what a user is seeing by the video recording function on smart phones. • Automatically updating the newest data through the server so that users' data will be updated at any time. • Discussing or experience sharing through social networking APP.

5. Concluding Remarks

Presenting artifact information by mobile devices is more powerful than general web presentation. Mobile devices such as tablet computers and smart phones have excellent capabilities in human-computer interaction, multimedia presentation and mobile computing, etc. With these capabilities, certain artifacts could be presented more deeply and more interactively. Users may gain a better visiting experience and have a higher learning efficiency. Museums could enhance their services by adopting this new technology to achieve their goals in exhibition, education, and research. The integration of mobile computing, cloud based database service, P2P streaming service as well as mobile GUI technologies creates an ideal “educational and entertaining” platform for mobile digital museum. The above-mentioned “Mobilizing Digital Museum” pioneering prototype developed by Lien Y. N., Jang H. C. *et al.* of National Chengchi University has paved a way for the museum to move forward to mobilizing their digital archives.

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