

## **u-Museum and u-learning: On Development of National Palace Museum's Mobile Apps**

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### **Abstract**

*With the development of various mobile technologies such as Wi-Fi, Bluetooth, App and smartphone, museums have started to apply mobile technologies to develop their u-learning service to achieve the “Ubiquitous Museum”. Although many studies discuss the application of mobile technologies in museums, few have explored how the museums develop the App to achieve u-learning based on museum learning theory. This study treats the National Palace Museum (NPM) as the target, and adopts the Falk & Dierking’s museum learning theory framework to explore the development of Apps by the NPM. In Taiwan, the NPM developed three different Mobile Apps starting from 2012, and hoped to increase visitors’ u-learning results. Both case study and comparative method were used in this research; the environmental context of NPM serves as the case study, while a comparison was done between the three NPM Apps by applying Falk & Dierking’s learning theory. The research results show the emphasis of the three NPM Apps’ orientations before and after visiting the museum, during the visit of the museum and while visiting a particular exhibition. Due to the differences in their orientations, the three Apps are very diverse in their designs of educational resources, core functions, content arrangement, audio-video functions and educational games, and how the use of mobile technology and the business model also differ.*

**Keywords:** *Mobile Technology, Apps, Museum Experience, Museum, Education*

### **1. Introduction**

Museums have long considered themselves as educational institutions [1], in addition to being institutions for the preservation, research and showcasing of cultural heritage. In the era of ubiquitous technology, museums face the new issue of applying wireless technologies and mobile technologies to promote learning in the u-society. As smartphones have become the essential device possessed by modern people, and apps are commonly used, how museums offer u-learning functions in the u-society has become an even more urgent topic.

With the popularization of mobile devices such as smartphones and tablet PCs, the downloading and usage of application software (apps) have become part of modern everyday life, changing the way that people communicate and learn. Given the predominance of these new communication technologies, it is necessary for museums to adapt, adjust their information service strategy, and develop suitable mobile applications to enhance the learning outcomes of museum visitors in an era dominated by mobile communications. In view of the above, discussions and studies related to Apps have received significant attention from the museum community in recent years, particularly in the U.S. and Europe, where much related research has already been conducted. Examples of such research are the large-scale status survey of museum mobile services conducted by the American Alliance of Museums (AAM) [2]. However, research on museum mobile Apps is still significantly lacking in Taiwan or the greater China region, and research from

the perspective of visitors' general or learning needs are particularly scarce. As a result, museums with collections of mainly Taiwanese or Chinese contents often lack good reference material (such as research or case studies) when developing their Apps.

In order to enhance museum visitors' u-learning effects, when developing u-service or Apps, museums need to understand how visitors derive meaning during a museum visit or when using museum resources [3]. Given the above, this study drew on Falk & Dierking's museum learning theory and, using three Apps developed by the National Palace Museum as examples, conducted a comparative study to investigate the development focus, functions, contents and technical characteristics of these three different Apps. The aim of the study was to explore the significance of these Apps in enhancing visitors' u-learning results in a museum learning context, and to provide reference for other museums when they develop Apps and promote u-learning.

## **2. Background: Mobile Technologies and Museum Learning**

### **2.1. Current Status of Mobile Technology Application by Museums**

Museums around the world have started to develop a variety of Apps in recent years, along with promoting various other types of mobile technology services. Renowned large museums, such as the Louvre, MoMA, the U.K.'s National Gallery, and the Tate Museum, are all pioneers in the development of museum Apps. In fact, museums started exploring potential applications of digital media technologies in regard to providing mobile services, as early as the 1990s, long before the popularization of Apps and smartphones; technologies such as podcasts, e-book readers, PDAs, traditional phones, and game consoles were all mobile service options explored by museums [4,2]. According to research on this period of development, there were more than 101 relatively important mobile service and wireless service projects from museums around the world in 1995 alone [4]. With the gradual perfecting of mobile technologies, the maturing of wireless technologies, the significant reduction in costs, and the formation of App uploads and usage mechanisms, mobile services provided by museums have shifted from being mainly based on podcasts or PDAs in the past, to the current emphasis on smartphones and App development.

According to a survey by the American Alliance of Museums (AAM), more than half of the 740 U.S. museums surveyed provide services related to mobile technology, with 13% of the museums providing both traditional mobile services and new types of mobile services based on smartphones, and 36% of the museums providing only new types of mobile services. The survey also revealed that 30% of the museums provide QR Code services, while 13% of the museums engage in the research and development of exclusive Apps; cross analysis revealed that the proportion of large museums engaged in App development is higher than small and medium museums, while QR Code services are widely welcomed by small and medium museums. Compared to 2011, the application ratio for QR Code and App development in the U.S. museum community increased by 800% and 151%, respectively, while the ratio for traditional voice navigation services decreased by 21%. In addition, a program named Pocket Proof/Learning Time also conducted a questionnaire survey among museum professionals in the U.S. and other countries around the world. Survey results showed that more than half of museum employees support or recognize that museums should develop mobile technologies or services such as Apps [5]. However, no large-scale surveys like the one conducted by the AAM have been performed in Taiwan to date.

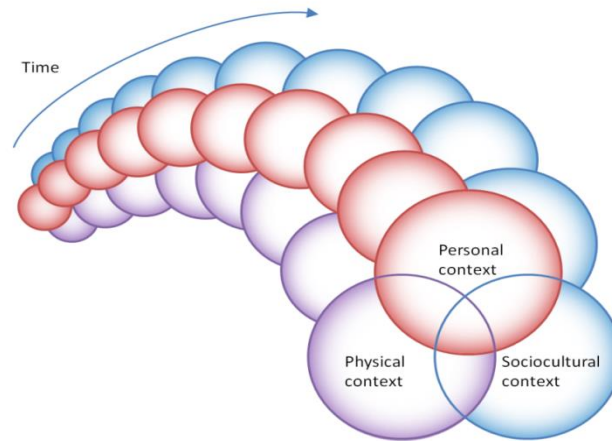
### **2.2. Museum Education and Museum Experience**

**2.2.1. Museum Education:** Education is one of the main functions of museums, and

museums have been positioning themselves as education and research institutions for the past few decades. In the history of museum development, there has been a strong emphasis on education since the establishment of museums in the nineteenth century [6,7]. Although museums are educational institutions, the characteristics of their educational activities differ from the formal education offered in schools [8,9]; generally, museum education is a form of informal education and a part of education in its broader sense. Furthermore, the educational function of museums is mainly accomplished through exhibitions and educational activities, whereby museums communicate with visitors to generate an experience for them, and subsequently share knowledge with them [10]. In the museum context, a visitor is allowed to select exhibits, explore exhibition information, discover messages in the exhibition, and even interact with exhibits, thereby acquiring knowledge and constructing personal meaning throughout the process. Therefore, museum learning can be regarded as a series of processes for the construction of personal meaning, rather than the mere acquisition or transfer of fixed information [8]. Since museum education emphasizes the construction of personal meaning through experience, it can also be freely selective, proactive and non-linear, and may even contain leisure elements at times [11].

**2.2.2. Museum Experience:** As experience is the core element of museum learning, it is an important consideration when museums are developing Apps or designing u-services based on mobile technologies. Museums need to have a complete understanding of museum experience, before App design and visitors experience can be integrated effectively to achieve the objective of museum's u-learning. The experience that museums can create for their visitors usually comprises both experience within the museums and extended experience generated outside of the museums themselves [3-12]. The form of museum experience may be educational, recreational, aesthetic, immersive, or a combination of these properties. The formation of museum experience is also influenced by various personal or social factors, and hence the museum experience of one visitor will never be exactly the same as another's [12].

In order to further clarify the characteristics of the museum experience and explain the relationship between the museum experience and museum learning, Falk and Dierking proposed the "Interactive Experience Model" in the 1990s, which was subsequently revised as the "Contextual Model of Learning." The model proposed by Falk and Dierking was primarily used to illustrate the components and mode of operation of the formation of museum experience, as well as to describe how the museum experience generates visitors' learning effects in museum contexts. Falk and Dierking suggested that the museum experience is primarily formed by a combination of personal, physical and sociocultural contexts. Personal context refers to museum visitors' personal interest, background knowledge, expectations, motive for visit, prior experiences and perceptions related to museums. The sociocultural context comprises the influence and behavior of visitors when they visit in a group (such as with family, classmates, friends, or tours), and the interactions between visitors and museum employees. Physical context includes a museum's building, services, exhibits, directions, atmosphere, facilities and smells. A visitors' museum experience is the outcome of the continuous interplay among personal, physical and sociocultural contexts. Usually, the personal context has the greatest influence on the construction of the museum experience before visitors visit a museum; the influence from the physical and sociocultural contexts then begin to impact the experience during a visit. After the visit, if the museum experience comprises rich contents from all of the three contexts, then the visitors may remember the experience for a long time, thereby producing the learning effects [3].



**Figure 1. Falk & Dierking's Contextual Model of Learning**

In view of the above, in order for museums to achieve educational and learning effects through the development of Apps and related mobile technology services, designers must consider how museum Apps can play a role in shaping personal, physical and sociocultural contexts.

### **2.3. Issues Related to the Use of Apps by Museums**

As the viability and accessibility of u-learning continue to improve, museums need to thoroughly consider various issues related to App development, as well as how the museum experience can be incorporated into the App development process. In order for the characteristics of museum Apps to be effective, as well as to develop u-learning in museum contexts based on the extension of the museum experience, museums need to consider several issues when developing Apps, as follows.

**2.3.1. Development Strategy:** The forms that museums take are quite diverse, and their sizes and modes of operation differ greatly; their objectives and mechanisms for developing Apps vary significantly as well. Some museums develop Apps entirely independently, while others collaborate with agents or completely outsource such development. Additionally, various aspects of Apps, such as text contents, multimedia contents, publication platforms, software and hardware selection, and promotion of the Apps, vary significantly between museums [13-14]. Therefore, when museums are developing Apps, they need to formulate the most appropriate development plan for their particular institution, based on conditions, such as the characteristics of their collections, the size and purpose of the establishment, and their development direction and operating status. Naturally different App strategies are needed to fulfill different App development objectives [15]. Moreover, as small museums lack information technology personnel and funding, their modes of App development and operation will differ from those of large museums.

**2.3.2. Technology Selection:** For the operation of Apps, there are many different options in terms of information technology; hence, museums need to determine the technology and technology-related options to be adopted during their App development, based on factors such as the museum scale, budget and human resource, and whether both iOS and Android platforms need to be developed, or if only one. They may also need to consider if an iPad version of the App needs to be developed, or only the responsive design for iPad, or if it should not be developed at all. Museums need to select the type of technology to be used for Location-Based Services (LBS), be it Wi-Fi, GPS, or QR-Code; museums also

need to consider whether it is necessary to develop Device-Native Apps, or if a mobile web page (Web-Based App) would be sufficient to meet visitors' demand [16].

**2.3.3. Content Planning:** Most of the objectives for museum App development concern the visitors, in particular, their participation and education. Therefore, the design of museum App content is dependent on the focus of App development, *i.e.* which aspect of the visitors' needs the App seeks to address. In addition, there is also a need to create content and experience modes that differ from traditional web pages, PDAs and audio orientations. Before developing an App, museums need to carefully plan the following: whether it will be mainly based on visual or audio data; whether it is mainly to be used by the visitors onsite or in other places outside the museum; whether the organization of content aims to allow freewill selection by the visitors, or if it is to have a curatorial direction; how detailed the introduction of individual collections should be in the App; how the content should be organized; how boredom can be avoided; and whether video and audio contents need to be imported [17-18].

**2.3.4. Function Design:** A museum's App design plan needs to determine how functions should be designed, and whether or not they should be included in the museum's Apps. For example, museums need to consider whether Apps should include social network functions (and which social networks should be included), and whether visitors' behaviors and positions in the museum need to be tracked and the record of their usage of museum Apps analyzed, or if this would lead to privacy issues [19]. They need to consider whether games should be included in the Apps, and how they should be designed. Museums need to decidewhether there is a need to provide functions that allow visitors to evaluate collection preferences, or select and save certain collections via the App. Finally, App designers need to determine how audio or video should be presented, whether or not operations can be pre-set, and whether or not augmented reality (AR) can be applied [20].

**2.3.5. Business Model:** Generally, apart from a few large-scale museums, the majority of museums face significant shortages of funds for information technology personnel and for information technology-related projects; hence, museums cannot be compared with general commercial organizations. Therefore, the sources of funding, the cost of implementation, and the cost of updates and maintenance require particularly careful consideration during the development of museum Apps. Museums also need to consider whether the download of Apps will be free or if users are to be charged. According to scholars and experts, the business models that can be applied to museum Apps may include development using sponsored funds or grants, a combination of free and fee-based downloading, paid subscription by users, the open data model and the placement of advertisements in Apps [2]. In the experiences of museums in the U.K., the provision of free museum Apps attracted many downloads, but the number of downloads dropped drastically once the App required a fee [18].

### 3. Research Method

This study adopted the comparative method as its main research method for studying the three different Apps developed by the National Palace Museum during the same period. The study also adopted the approach of a case study, whereby the contexts of the palace and the museum were used as the main backgrounds for comparison. This study cited the theory of museum experience and museum learning that is most widely accepted by the museum community, Falk and Dierking's "Contextual Model of Learning," in order to compare the impacts of the three different NPM Apps on learning.

The comparative method is a well-established research concept and method, and its essence of comparative study has been used to investigate many probing research

questions in various subjects and research areas; comparative study is most widely applied in the fields of educational studies and library science [21]. Comparative study is the comparison of two or more research objects (such as organizations, regulations, or people) under the same standard, in order to identify similarities and differences. The procedures generally follow the same sequence: description, explanation, juxtaposition, comparison and conclusion [22]. Although the main objective of the comparative method is to compare two or more research objects for their differences and similarities, it should also be noted that only objects of the same type, category and standard can be compared [23]. Conclusions will not be objective if objects of completely different natures are compared. Therefore, this study has taken only the three Device Native Apps developed by the National Palace Museum as the comparison objects, and excluded mobile web pages, in order to ensure more accurate and in-depth exploration into the significance of the application of museum Apps to museum u-learning.

## 4. Research Results

The National Palace Museum developed three different Apps: “Discover NPM”, “NPM Insight” and the “Qian-Long Chao App,” between 2012 and 2013. Among these, “Discover NPM” and “NPM Insight” were App projects developed by the National Palace Museum itself, while the “Qian-Long Chao App” was developed for its New Media Art Exhibition in 2013. The following section explores both the comparisons of these three Apps from various aspects and the significance of the individual Apps to u-learning.

### 4.1. Content Design

**4.1.1 Content Planning:** In terms of content planning, the three Apps have unique designs, reflecting their respective design objectives; as a result, the operation sequence of visitors using the Apps will also differ. Firstly, when using “Discover NPM,” visitors will note that the content of the App is divided into categories such as “Traffic Direction”, “Museum Introduction”, “Visit Information”, “Precious National Treasures” and “Learning Assistant.” The main screen is shown in Figure 2. The design of “NPM Insight” is completely different, as its main content consists of the locations of the permanent exhibition of artifacts, the types of artifacts on various floors and exhibition halls, and the material classification of artifacts. The screen introducing the artifacts on various floors and exhibition halls is shown in Figure 3. As for the “Qian-Long Chao App,” the introduction focuses entirely on the various interactive exhibition installations at the National Palace Museum’s Qian-Long Chao New Media Art Exhibition, and has no categorization or further orientations. The screen is shown in Figure 4.



Figure 2. Main Screen of “Discover NPM”



Figure 3. Main Screen of “NPM Insight”



Figure 4. Main Screen of “Qian-Long Chao”

**4.1.2. Organization of Collection Information:** Collections are the foundation of museum operations, and the focus of museum learning comprises the knowledge, backgrounds and aesthetics concerning these collections. Therefore, during the design phase of the NPM's three Apps, the organization of collection information differed according to the differences in the design objectives of the Apps. The "Discover NPM" App carefully selects and introduces 100 pieces of the NPM's highly renowned or representative collections, and provides visitors with a search option for these 100 pieces through a sequence of character strokes; whether or not these collections are on exhibition or where they are located is not described. The organization of the collection information for "NPM Insight" is completely different: over 300 pieces of the collection are described or introduced in the "NPM Insight" App, and the organization of these collection pieces is mainly based on the locations of the NPM's exhibition halls and floors. Collections that are not exhibited will not be featured in "NPM Insight," as shown in the screen in Figure 5. As for the "Qian-Long Chao App," it introduces only the interactive works exhibited in the NPM's New Media Art Exhibition, and does not directly introduce the National Palace Museum's collections. Its introduction method is also essentially the same as a printed exhibition brochure.

**4.1.3. Orientation Information:** Orientation information is an important link in the services for museum visitors and a part of the environmental context, which is an element of the formation of museum experience. Therefore, how Apps should be applied to allow visitors to access orientation information effectively and conveniently, as well as to enhance the quality of their experience in the physical context, is an important point to be addressed during the design of the Apps. A large portion of the content in "Discover NPM" relates to orientations, including traffic, driving routes, opening hours and cost of tickets, nearby attractions, floor introduction and floor plans, explanation of orientation information, and recent news. By comparison, "NPM Insight" has less content in this respect, and the content is also simpler, including only the opening hours, video, floor plan and the cost of tickets. As for the "Qian-Long Chao App," orientation information has not been included in the App design; instead, a link to the National Palace Museum's website is provided for visitors to obtain relevant information.

**4.1.4. Learning Resources:** A very important part of museum education is reinforcing visitors' memories through experience, in order to improve learning effects. In order to achieve its museum education goal, the NPM has designed tools that could help to reinforce the memory of art history or artifact information in the "Discover NPM" App, so that visitors can easily access knowledge related to the artifacts in the NPM, even when they are not at the museum. These tools include a dictionary for terms related to the NPM's artifacts, a perpetual calendar for artifact history, and links to digital learning websites. The "NPM Insight" App, on the other hand, has provided a timeline for the artifacts to help visitors with memorization. There is no such design in the "Qian-Long Chao App."

**4.1.5. Audio and Video Data:** When presented in audio or video form, artifact-related content is likely to leave a deeper impression on visitors, and the effectiveness of such forms of presentation would be much greater than pure text data, and hence more beneficial in regard to the reinforcement of memory and the learning effects. Currently, many museums have produced different types of films or multimedia materials that are published and transmitted via different means to enhance visitors' learning effects. When developing the "Discover NPM" App, the NPM specifically filmed a short movie story, *i.e.* a mini film, aimed at promoting the "Discover NPM" App. The mini film is also embedded in "Discover NPM" for visitors to view. A short promotional video clip was also produced for the "NPM Insight" App. However, the length of this film is shorter than

the “Discover NPM” film, and its shooting style is skewed towards a montage, with the playback of the clip linked to YouTube. The nature of the “Qian-Long Chao App” is more of a celebrity interview, in which celebrities’ opinions of the National Palace Museum’s New Art Exhibition are recorded in a short clip for viewing. This film is also linked to YouTube. The differences in content design for the three National Palace Museum Apps are compared briefly below in Table 1.

**Table 1. Content Design for the Three National Palace Museum Apps**

	NPMs’ Apps		
	Discover NPM	NPM Insight	Qian-Long Chao App
Content Planning	Focus on NPMs’ environment, service and representative collections	Focus on locations of the permanent exhibition of artifacts	Focus on NPMs’ New Media Art Exhibition
Collection Information	100 representative collections	Over 300 collections organized by location of exhibition hall	Focus on interactive installation of New Media Art Exhibition
Orientation Information	Detailed content in Orientation	Less content in Orientation	Link to NPM’s official web site
Learning Resource	Dictionary for art term, perpetual calendar for artifact history, link to e-learning site	Timeline Function	None
Audio & Video Data	Promotional Mini film embedded in the App	Playback of the clip linked to YouTube	Playback of the clip linked to YouTube

## 4.2. Function Design

**4.2.1. Bookmark or Sequencing Functions:** The National Palace Museum has an extremely large collection of over 690,000 artifacts, and more than 300 or 400 pieces of different artifacts may be exhibited at the same time, incorporating many different types of artifacts, including utensils, calligraphy, paintings, rare books, and archives. In view of the extremely large quantity of collections and exhibits, the App design has to focus on how to enhance visitors’ memory and stimulate the creation of emotional or aesthetic bonding between the visitors and specific collection pieces. Therefore, the NPM has designed personalized bookmarks and preference sequencing in its Apps. In the “Discover NPM” App, visitors can evaluate their degree of preference for artifacts, whereas in the “NPM Insight” App, visitors can select the artifacts that they like and place them into bookmarks; these bookmarks can be organized or edited according to the different floors on which the artifacts are exhibited. No similar function is provided in the “Qian-Long Chao App.”

**4.2.2. Social Networks:** The use of social networks has become a part of daily life for many modern populations, shaping entertainment, socialization, work and learning. In



theories related to museum experience, the interaction of the visitors with others is an important factor influencing the effectiveness of museum learning. In order to use mobile tools to enhance the learning effects for museum visitors and strengthen visitors' memory of artifact knowledge through their social context, all three NPM Apps have incorporated social network mechanisms. For the "Discover NPM" App, users have the option to receive information via tools such as Facebook, Twitter and Blogger. The "NPM Insight" App has taken this function further, allowing users to publish and discuss specific artifacts through their Facebook and Twitter accounts, as shown in Figure 5. As for the "Qian-Long Chao App," users are allowed to share the results of in-App AR games with their friends via Facebook, E-Mail and LINE, but the App was not designed to enable the publication of exhibits or artifact information. This function is shown in Figure 6.

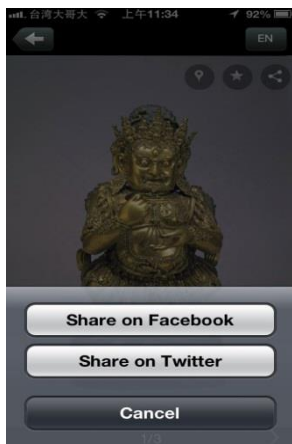


Figure 5. Social Network function of "NPM Insight"

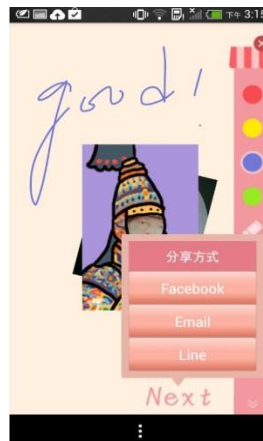


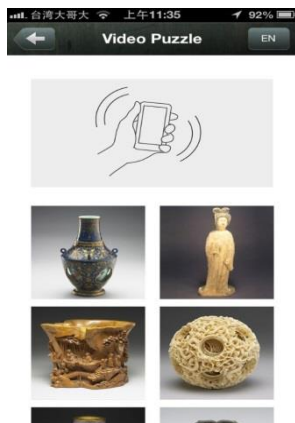
Figure 6. Social Network Function of "Qian-Long Chao"



Figure 7. Artifact Puzzle Game of "Discover NPM"

**4.2.3 Educational Games:** For the design of Apps, developers can make use of the various functions of mobile devices, such as touch control, blowing, rotation, and sound and light animation, in order to design games that provide users with innovative game experiences. The same is also true for museum Apps; many museum Apps have been designed to incorporate various interesting mini games. In addition to helping visitors memorize information, while providing entertainment, such games enable the visitors to experience artifacts at locations outside the museum. The National Palace Museum's "Discover NPM" App provides different types of games, such as artifact puzzles, blowing, finger touch control and an artifact memory contest; an example of one of the games is shown in Figure 7. As for the "NPM Insight" App, various games, such as artifact puzzles, phone swaying, and artifact searches using Augmented Reality (AR) are included. The game screen is shown in Figure 8. As for the "Qian-Long Chao App," there are a few other types of games apart from the exhibition style e-card drawing game and a simple AR group photo game; the games for this App also have less association with the NPM's artifacts.

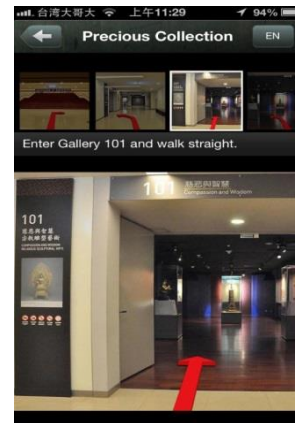
**4.2.4. Augmented Reality (AR):** The application of AR is one of the most attractive areas in App usage. Many museums started to apply AR technologies when they first started introducing Apps. However, the adoption of AR technologies is also dependent on the nature of the museum's artifacts and the design objective of the App. None of the three Apps designed by the National Palace Museum have made substantial use of AR; they have applied AR technologies only in the App games.



**Figure 8. Swaying game of “NPM Insight”**



**Figure 9. QR code Services of “NPM Insight”**



**Figure 10. Indoor Street-view Services of “NPM Insight”**

The differences in the function designs of the three National Palace Museum Apps are compared briefly below in Table 2.

**Table 2. Function Design for the Three National Palace Museum Apps**

	Discover NPM	NPM Insight	Qian-Long Chao App
Bookmark function	Visitors can evaluate their degree of preference for artifacts	Visitors can select, organized or edited bookmarks according to the artifacts' location	None
Social Network	Using Facebook, Twitter and blogger to share NPMs' news	Using Facebook and Twitter to share artifact information	Using Facebook and LINE to share the results of games
Educational games	Artifact puzzles, blowing, finger touch control, and an artifact memory contest	Artifact puzzles, phone swaying and artifact searches using AR	Exhibition style e-card drawing game and AR group photo game
Augmented reality	None	AR Game	AR Game

### 4.3. Selection of Technology

**4.3.1. Location Based Services:** In a time of the constant advancement in mobile communications and wireless communication technologies, there are many ways for App designers to develop an App's positioning services. Positioning services have been widely used in museum Apps in recent years. For museum Apps, positioning services are highly effective in enhancing visitors' experience, as well as the interaction between visitors and exhibits during an exhibition tour; in other words, positioning services can be applied directly to strengthen the museum's physical environment directions or artifact explanations, thereby enhancing visitors' museum experience in terms of environmental

context experience. For the NPM Apps, the “Discover NPM” App provides GPS positioning services for the entire palace district, but such services are not available for the palace’s interior premises. Positioning services for the palace interior are provided in the “NPM Insight” App. However, because of the poor reception of signals in the exhibition halls and the prohibition on taking photos using mobile phones, the design of “NPM Insight” uses two different methods to direct visitors through different exhibition halls, and to inform them of their locations. The first method uses QR Codes in conjunction with the floor plans of the exhibition halls; the screen is shown in Figure 9. In another method, the indoor street-view of the exhibition halls is displayed in the App, with red arrows being used to guide visitors’ movements, as shown in Figure 10. No positioning services are provided in the “Qian-Long Chao App.”

**4.3.2. Dissemination Platforms and Versions:** The three National Palace Museum Apps have different designs and considerations for their respective platforms and versions. The “Discover NPM” App has both iOS and Android versions for mobile phones, but no tablet PC version. As for the “NPM Insight” App, although there is no exclusive design for tablet PCs, it has incorporated responsive designs for use by tablet PCs in addition to iOS and Android versions for mobile phones, so that tablet PC users can use the App as well. The “Qian-Long Chao App” has no iOS or tablet PC versions; only an Android version for mobile phones is available.

**4.3.3. Modes of Update and Maintenance:** Since the three National Palace Museum Apps have different designs and contents, the respective operations of their content updates and maintenance also differ. Firstly, as there is relatively less direct connection between the content of “Discover NPM” and the detailed contents of exhibitions, there is also relatively less need for updates. However, when there is a change in the cost of tickets or the museum’s opening hours, the content still needs to be updated. When such a need arises, the National Palace Museum will propose its budget and the content to be updated, and then vendors will assist with the actual content updates. In the event of iOS or Android software updates, increases in the size of mobile phone screens, or when content or programs need to be debugged, vendors will also assist in the actual updates or maintenance. As for the “NPM Insight” App, which provides detailed introductions to the various artifacts being exhibited, its content needs to be updated substantially once an exhibition ends and a new exhibition begins, and a significant amount of labor and time is usually needed to confirm the content to be updated. The budget and the content for the updates will be proposed by the museum itself, while vendors will carry out the actual update work. The “Qian-Long Chao App,” on the other hand, is designed specifically for the New Media Exhibition that lasts only for a few months; hence, the App will be decommissioned once the exhibition ends. Thus, issues relating to updates or maintenance will not arise. The differences in the selection of technologies among the three National Palace Museum Apps are briefly compared below in Table 3.

**Table 3. Selection of Technologies for the three NPM Apps**

	Discover NPM	NPM Insight	Qian-Long Chao App
Location based service	GPS positioning services for the entire museum district	QR Code, Indoor street view	None
Dissemination platforms and versions	iOS and Android for smartphone	iOS and Android for smartphone, Responsive designs for tablet PCs	Android for smartphone
Modes of update and maintenance	Vendors will assist with the actual content updates	Vendors will assist with the actual content updates	None

#### 4.4. Development Model and Business Model

**4.4.1. Development Model:** The development model of museum Apps varies according to factors such as museum scale, human resources, funding, and information policies. The development model of museum Apps can generally be classified into independent development, museum-led development with vendor assistance, or fully outsourced development; the mechanisms for the provision of content, production of audio and video material, implementation, software and hardware support, and evaluation of usage effectiveness are determined according to the needs of different museums [14]. The National Palace Museum’s “Discover NPM” and “NPM Insight” Apps were developed under the model in which the development direction was led by the museum, but the actual development work was carried out by vendors. The “Qian-Long Chao App” was developed via full outsourcing, whereby the exhibition set-up team for the New Media Art Exhibition undertook the App development according to the contents of the exhibition.

**4.4.2. Source of Development Funds:** Because museums often have insufficient budgets for information technologies, issues related to the source and scale of funding must be considered during the development of Apps. As the process of App development is highly flexible, their functions can be designed to be either very complex with abundant contents, or very simple, depending on conditions such as the nature of the museum, the development objectives, and resource availability. The NPM’s “Discover NPM” and “NPM Insight” Apps were developed using project funding from government grants, and the funding was rather abundant in terms of scale, whereas the funding for the development of the “Qian-Long Chao App” was absorbed in the exhibition funding for the New Media Art Exhibition, along with limited sponsorship. Hence, the scale of funding for this App was relatively small, and the development objective of the App was solely to provide onsite support for the exhibition.

**4.4.3. Business Model:** Although the competition between Apps is very intense on App sales platforms such as the Apple Store or Google Play, and the sales of many Apps are not ideal, museums can still consider whether their App should be fee-based, and what charging methods should be adopted if Apps are not free. As stated above, various types of commercial models are available for museum Apps, such as those that provide free

downloads, models based on a combination of free and paid Apps, and Apps that integrate the placement of advertisements. The use of these commercial models is fully dependent on whether museums see their Apps as projects of pure museum educational media materials, commodities, or a combination of both; whether or not museums expect to gain profits from the sale of Apps; and museum policies relating to authorization and sales. The National Palace Museum’s “Discover NPM” and “NPM Insight” were both developed using project funds from government grants. Hence, they are positioned as pure museum educational media materials, and may be downloaded completely free of charge. The “Qian-Long Chao App” was developed using part of the set-up funds for the New Media Art Exhibition, and is positioned as onsite support for the exhibition. Hence, this App could also be freely downloaded. The differences in the development models and business models among the three National Palace Museum Apps are briefly compared below in Table 4.

**Table 4. Development and Business Model for the Three NPM Apps**

	Discover NPM	NPM Insight	Qian-Long Chao App
Development model	Development direction was led by the museum; the actual development work was carried out by vendors	Development direction was led by the museum; the actual development work was carried out by vendors	Full outsourcing
Source of development funds	Funding from government grants	Funding from government grants	Developed using part of the set-up funds for the New Media Art Exhibition
Business model	Free for download	Free for download	Free for download

## 5. Conclusion and Suggestions

Comparison of the three NPM Apps, *i.e.* “Discover NPM”, “NPM Insight” and the “Qian-Long Chao App” revealed that although all three of these Apps were developed by the NPM, their characteristics and roles in the promotion of museum education are completely different.

In terms of content, “Discover NPM” uses information related to the entire NPM district (such as traffic status and an introduction to the district) as its main division structure. The App contains a relatively large amount of orientation information, along with a lot of design features and games related to learning resources; the collection information largely focuses on the introduction of artifacts that are highly renowned or representative. The featured artifacts may not be on exhibition, and the social network functions are not related to specific artifacts. Therefore, according to the theory of museum experience, “Discover NPM” emphasizes the stimulation of “before-exhibition” and “after-exhibition” experiences among visitors. “NPM Insight,” on the other hand, places particular emphasis on the floor location of artifacts in the museum, *i.e.* which floor each artifact is on, lines of movement, and the positioning of floors and exhibition halls. Individual artifacts can be shared through social networks, and there is relatively little orientation information. As such, “NPM Insight” emphasizes the actual environment once the visitors enter the National Palace Museum. According to the theory of museum

experience, “NPM Insight” emphasizes the stimulation of “during-exhibition” experiences in the visitors, and possesses partial “after-exhibition” functions. As for the “Qian-Long Chao App,” its content organization and game design are completely based on the interactive works in the Palace’s New Media Art Exhibition, along with celebrity interviews, and have little connection with the artifacts in the National Palace Museum. Furthermore, as there is extremely little orientation information functionality and no learning resources in the App; the App is limited to the function of stimulating visitors’ “during-exhibition” experiences. Based on the principles of informal education, both “Discover NPM” and “NPM Insight” have also employed as much film and enhanced visual design aesthetics as possible, in order to provide visitors with casual, recreational and aesthetic ways to be in contact with the artifact knowledge of the National Palace Museum. The provision of diverse artifact information and options such as the movement lines of artifact exhibits allow visitors to make selections at freewill, which is in line with museum education’s principles of independent and freewill selection; games are also integrated into the Apps to meet the requirement for leisure characteristics in museum education. Based on the museum Contextual Model of Learning proposed by Falk and Dierking, museum learning effects are generated from museum experience, which is formed by personal, physical and social contexts; these contexts interact with one another before, during, or after an exhibition to fulfill their functions. From the perspective of the museum Contextual Model of Learning, each of the three NPM Apps performs a slightly different role in the formation of museum experience.

### **5.1 Personal Context**

The purpose of the extremely detailed orientation information, floor perspectives, GPS positioning of the extended museum district, and the 100 pieces of carefully selected renowned and representative artifacts in the “Discover NPM” App, is to raise the expectations of the visitors and enhance their understanding of the environment and services of the National Palace Museum. Thus, even before they enter the National Palace Museum, the visitors already possess a certain level of knowledge regarding the overall environment of the National Palace Museum and the nature of its representative artifacts, and they may even be curious or already have expectations. By providing some information related to the National Palace Museum and the artifacts before the visitors enter the museum, the information may become part of the visitors’ background knowledge, helping to fully stimulate the personal context factor in the visitors’ museum experience. However, the “NPM Insight” has limited information and functions in this regard, and the “Qian-Long Chao App” has almost no functions or resources relating to this personal context. In terms of learning resources, “Discover NPM” emphasizes artifact knowledge, while “NPM Insight” emphasizes the timeline, both of which are closely related to a museum’s orientation concept and can be used to strengthen the personal context of the visitors. However, the learning resources of “Discover NPM” focus on applications before and after exhibitions, whereas the learning resources of “NPM Insight” are similar to the function of a museum’s orientation hall, and emphasize before-exhibition applications. As for the design of App games, the games in “Discover NPM” are designed based on several artifacts selected from the 100 most renowned pieces, with the aim of enhancing the visitors’ experience in the personal context before or after exhibitions. With “NPM Insight,” however, parts of the game require the application of the AR function for a search of replica artifacts in the National Palace Museum during a “treasure hunt.” Although the objective is still to enhance the personal context, it is mainly achieved after exhibitions.

### **5.2. Physical Context**

For the “NPM Insight” App, the main design objective of some functions is to

stimulate the visitors to increase their familiarity with the internal environment and the exhibited artifacts of the NPM. Functions such as the division of artifacts according to floors; the selection, organization and storage of preferred artifacts by museum area; information about the positioning of various exhibition halls; and the virtual indoor movement line guides; enhance the environmental context factor of visitors' museum experience. Since the "Qian-Long Chao App" focuses on the introduction of specific exhibitions, its function is similar to that of "NPM Insight" in this respect.

### 5.3. Sociocultural Context

"Discover NPM" includes functions that allow visitors to share the developments and news related to the entire museum district via social websites, while "NPM Insight" allows visitors to share information about individual artifacts, and the design of "Qian-Long Chao App" allows visitors to share game results. The primary objective of all three Apps is to enhance the social context of the visitors' museum experience, but they each have a different focus. The social network function of "Discover NPM" has no direct link to individual artifacts and is focused on "after-exhibition" experiences. "NPM Insight" allows for the publication and sharing of information about individual artifacts, focusing on "during-exhibition" experiences. The social network function of the "Qian-Long Chao App" is also relatively skewed toward the "after-exhibition" context.

Based on the Contextual Model of Learning proposed by Falk and Dierking, Table 5 below provides a brief description of how the three Apps fulfill their functions in the personal, physical and sociocultural context of the museum experience, and whether their focus is before, during, or after visit an exhibition.

**Table 5. Relationship Between the NPM Apps and Museum Experience**

	Discover NPM	NPM Insight	Qian-Long Chao App
Before-exhibition Personal contexts	Detailed orientation information District GPS positioning 100 representative artifacts Mini promotional film in App	Some Service information Promotional film (YouTube) Timeline for artifacts	Service information is provided through a link to the NPM's official website Promotional film (YouTube)
During the exhibition Sociocultural context Physical context		Facebook, Twitter  Introduction of 300 artifacts, according to exhibition halls Floor movement line orientation QR Code positioning Artifacts can be bookmarked according to exhibition halls, based on personal preference	Introduction of exhibition content and exhibition items

After-exhibition			
Personal contexts	A variety of mini games related to cultural artifacts  Learning resources such as a dictionary and perpetual calendar  Sorting of cultural artifacts according to preference	AR treasure hunt games and other games	E-cards , AR games
Sociocultural context	Facebook, Twitter, Blogger		Facebook, LINE

An analysis of Table 5, along with the earlier description of how the three NPM Apps fulfill their functions in the personal, physical and social contexts of the museum experience, and whether their focus is before, during, or after an exhibition, reveals some interesting results. Although all three Apps use the NPM as their main subject, their development focus differs, as does the focus of their expectations for enhancing the visitors' museum experience. However, irrespective of which App the visitors uses, through the functions of the three Apps and the combination of informal education-based freewill selection, as well as the aesthetic design of the Apps, various museum experiences can be combined in the minds of the visitors to enhance the learning outcomes of the museum visit after they leave the museum. The Apps can also continue to be used outside the museum to accomplish extended museum experience objectives.

In conclusion, the three apps of the NPM have different emphases on the learning theory. Hence, when using mobile technologies to develop u-learning, the museum cannot treat Apps or u-service as a simple information tool, but should give overall consideration concerning the app design, including the museum's features and size, and consider the u-learning role to be played in the app or u-service in learning activities (*e.g.*, for the visitors before, during or after visit exhibition). Since visitors are the principle users of museum Apps, the design of an App needs to consider how the resources of the App should be focused, and the aspects of museum education that the App should emphasize for visitors realizing the main educational purpose of a museum. Moreover, the selection of suitable technologies, development models and business models also needs to be integrated for making more comprehensive design decisions. Museums should not follow fashions blindly when developing Apps; neither should they completely duplicate the App design methods of commercial organizations. After all, the target users for Apps of general commercial organizations are their customers, while the target users for museum Apps are the visitors. The operational goal of commercial organizations is profitability, while the goals of museums are service and education.

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