CRITICAL FACTORS PREDICTING THE ACCEPTANCE OF DIGITAL MUSEUMS: USER AND SYSTEM PERSPECTIVES

Shin-Yuan Hung
Department of Information Management,
National Chung Cheng University
Minhsiung, Chia-Yi, 62100 Taiwan
syhung@mis.ccu.edu.tw

Charlie C. Chen
Computer Information Systems,
Appalachian State University
Raley #2110, Boone, NC 28608
chench@appstate.edu

Hsin-Min Hung
Department of International Business,
National Dong Hwa University
Hualien, 97401 Taiwan
hsinminhung@mail.ndhu.edu.tw

Wen-Wen Ho
Department of Information Management,
National Chung Cheng University
Minhsiung, Chia-Yi, 62100 Taiwan
hwen@cwb.gov.tw

ABSTRACT

Digital museums are replacing traditional museums to inspire individual growth and promote culture exchange and society enrichment. However, the benefits of using the traditional museum to inspire visitors and promote the local economy may be compromised in the digital museum. This study attempts to offer insights on digital museum adoption from user and system perspectives. We extended the technology acceptance model (TAM) by incorporating computer self-efficacy and personal innovativeness as individual variables and media richness as a system characteristic. We launched a full-scale study with 441 users of 3 weather museums in Taiwan. We had 327 valid responses, a 74% response rate, from our target population. We conducted a regression analysis to investigate the potential influence of independent variables on the adoption of digital museums. Our results showed that both user and system characteristics have a positive influence on perceived usefulness (PU). A proper consideration of these three constructs can increase a user's PU and perceived ease of use (PEOU), thereby establishing a more positive attitude regarding the use of digital museums. Academic and practical implications concerning their adoption from user and system perspectives were drawn from these findings.

Keywords: Digital museum; Computer self-efficacy; Personal innovativeness; Media richness; Perceived ease of use

1. Introduction

Museums have many functions including interaction with real objects, cultural memory, inspiration, education, information dissemination, and research [Arvanitis 2007]. The proliferation of information communication technology (ICT) is transforming all aspects of museum operations while enhancing the traditional functions. Digital museums enabled by ICT can turn geophysical, temporal and resource limitations into advantages, such as encouraging more visitors, increasing the accessibility, transparency, the frequency and the duration of each visit, and enriching each visiting experience [Capriotti & PardoKuklinski 2012]. For instance, handheld devices are enabling users to visit museums at will. Family members can play games together to have fun educational experiences. Visitors can enter a digital museum to observe and play with virtual objects or fly/cross over to multiple museums to compare objects. A visitor can also digitally interact with other visitors or museum professionals. Museums can disseminate information via social media (e.g. Facebook, Twitter) so that visitors can closely follow any updates [Srinivasan et al. 2009a].Interesting objects can be located quickly with an effective search engine. They can also be viewed with different software. As such, digital museums can enable personalized viewing experiences. Lesson plans could be incorporated into the site plan providing educational experiences.

Unlike the traditional museum, digital museums are accessible virtually to visitors anytime, anywhere [Koening 1997]. They have the flexibility of touring museums at their own pace without having the physical constraints of doing so in a predetermined order [Flatley 1998]. The traditional concept of using a museum as a repository to store rare objects is being displaced with the contemporary concept of inspiring individual growth and promoting culture /awareness and societal enrichment.

Technical aspects of virtual museums have been the focus of existing literature. Aron [2011] developed mapping software to help visitors reconstruct digital images of long-lost cities and identify virtual museum exhibits of historical locations. Albanese et al. [2010] used intelligent browsing systems to make recommendations to users touring a museum based on their usage behaviors. Bonis et al. [2009] used a platform to personalize the delivery of semantic content based on the virtual touring history of its users.

As digital museums are becoming a prominent channel to increase the vitality of a society, examining the adoption of digital museums from an individual perspective is growing in importance. However, current literature lacks studies that examine digital museums from this viewpoint [Rockweiler & Weinhold 2005; Geber 2006]. Recognizing the gap, this study aims to offer a fresh view of digital museum adoption at an individual level based on the TAM.

In the next sections, we conduct a literature review and propose a theoretical model to integrate key factors related to the user and the systems that can encourage the adoption of digital museums. Hypotheses will be suggested to assess the relationships between constructs of the proposed model. Research methodology and data analysis methods are discussed with respect to data collection protocol, and the validity and reliability of data analysis methods. Findings will be reported and discussed with respect to academic and practical implications.

2. Literature Review

Digital museums have been adopting novel technologies (e.g. 3D, databases, virtual realities, flash, social media) to increase their visibility. The business community is also giving grants to museums and encouraging them to go digital in order to reach and benefit more users [Goodison 2011]. Along with the advance of information technologies come new features of digital museums, such as animated movies, interactive laboratories, podcasting speeches and lectures from museum professionals, web casting, self-paced learning lessons, and museum fans groups. However, it is unclear whether users are receptive to these features.

Digital museums, where all objects are digitally stored and displayed, are instrumental in giving visitors the freedom to appreciate objects in one of three presentation modes: (1) standard classification, (2) educational, and (3) grass-roots access [Srinivasan et al. 2009a].Traditional museums predominate in the first two presentation modes by having visitors receive authoritative interpretations for objects they find interesting. Digital museums are unique in the grass-roots access mode because they enable general users to participate in the process of understanding objects, such as providing descriptive information about objects, and influencing how objects could be better represented [Srinivasan et al. 2010].

However, the benefits of using the traditional museum to inspire visitors and promote the local economy may be compromised in the digital museum. A study has shown that users have difficulty engaging with objects represented by entries despite the fact that they can tag and comment on the museum’s catalog [Srinivasan et al. 2009b]. Unclear about the overall benefits of the digital museum movement, the management has begun directing attention to increasing user adoption of digital museums in order to justify their innovative solutions.

In consideration of the uniqueness of the digital museum, this study attempts to offer insights on its adoption from user and system perspectives. From the user perspective, his/her confidence in accepting and using new technologies is indispensable to the adoption of digital museums since they incorporate many novel technologies. These technologies vary according to the degree of media richness (audio vs. 3D). Users may find some of them easy to use or helpful, while others may find them challenging. Therefore, we proposed an integrated research model by incorporating computer self-efficacy and personal innovativeness as individual characteristics and media richness as a system characteristic together with the main constructs of the TAM, including a user’s PU and PEOU.

2.1. Understanding Digital Museum Adoption via the Technology Acceptance Model

The TAM asserts that PU and PEOU can influence the decision of users in adopting a new technology [Davis 1989]. Unless users are convinced of the usefulness and user-friendliness of a new technology to accomplish a task they will not form a positive attitude towards using it. PU and PEOU are key elements that can have a strong influence on the decision to adopt a new technology [Bagozziet al. 1992].

Digital museums are new technologies to many users because they are complex to use and include many variable elements. To increase the mass adoption of digital museums, their professionals need to strive to increase a user's PU and PEOU of them (Figure 1). The increase of PU and PEOU can potentially help digital users form more positive attitudes and intention towards them prior to their initial interaction. As a consequence, the actual use of digital museums should increase.

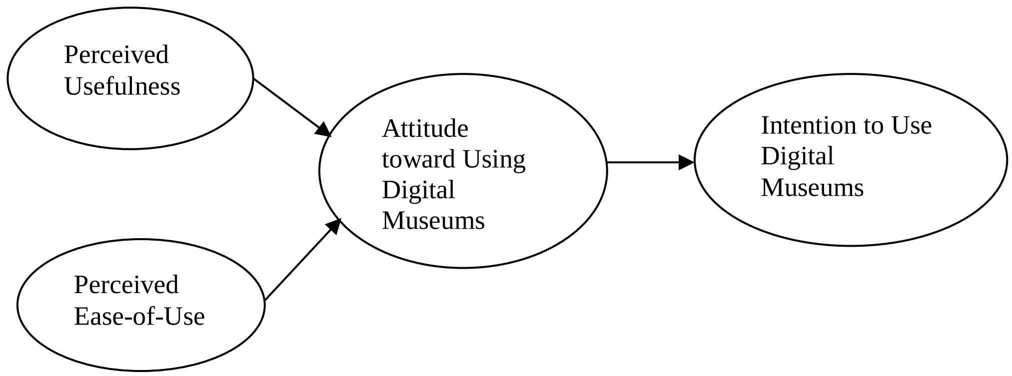


Figure 1: TAM for Digital Museums [Davis 1989]

The above four generic constructs of the TAM alone may not be able to present a holistic picture of digital museum adoption so computer self-efficacy, personal innovativeness, and media richness also need to be considered. Computer self-efficacy is concerned with the confidence and judgment of an individual to use computers in various situations [Compeau & Higgins 1995; Marakas et al. 1998]. Personal innovativeness denotes the tendency of an individual to adopt an innovation [Rogers 1995]. Media richness is the ability of media to generate useful information to help recipients improve their understanding of particular topics [Daft & Lengel 1984]. Digital museums are active adopters of novel technologies that have diverse degrees of media richness and this increased richness can potentially reduce the uncertainty and ambiguity of using them.

It is important to understand the potential influence of computer self-efficacy, personal innovativeness and media richness on the public perception. They are the primary users of museums yet individuals vary in their computer self-efficacy and personal innovativeness. Moreover, not all of them are receptive to the technologies incorporated in the digital museums. In order to validate our assertions about the importance of these three additional constructs, the following discussion will be focused on the potential influence of PU and PEOU.

2.2. The Effect of Computer Self-Efficacy on PEOU for Digital Museums

Digital museums enable users to become information creators and disseminators. These new roles require that users are confident in their computer capabilities/expertise before touring digital museums otherwise the fun activities will be seen as threats to be avoided. Museums can develop an Internet encyclopedia in which amateur historians are able to write and share their own historical knowledge [Swedien 2011]. Small museums, such as the Maryland Federation of Art, release a virtual tour of the gallery enabling their exhibits to attract visitors from different states and countries [Winslow 2011]. Users can take a 3D excursion to see more works, view close-ups of them, and learn more about artists and their works via links to their websites. A person's judgment of his/her capability to use computers in diverse situations is computer self-efficacy [Compeau & Higgins 1995]. Lack of it has been a major reason for some users not to adopt new technologies [Igbaria et al. 1995].

Computer self-efficacy originates from the self-efficacy concept. It is a person's beliefs in his/her capability to exercise control over actions that affect his/her life [Bandura 1994]. The improvement of perceived self-efficacy can help a person to make strong commitments, improve his/her motivation, reduce his/her stress, and create beneficial environments [Bandura 1986]. The examination of self-efficacy needs to take into consideration the context [Marakas et al. 1998].

Touring digital museums requires users to have a basic, intermediate, or advanced ability in computers depending on their personal goals. A strong belief in using different features of a digital museum may help a user become less stressful and committed to the process. If encountering difficulties, users with high computer self-efficacy are more likely to accept the challenge and adapt to the new environment.

Computer self-efficacy can exhibit an indirect influence via aPEOU [Igbaria & Iivari 1995]. As a subjective variable, it has a significant positive influence on PEOU [Venkatesh & Davis 1996]. It can be generally categorized into task-specific and general computer self-efficacy [Marakas et al. 1998]. Since the use of digital museums requires that a visitor have these two kinds of computer self-efficacy, the findings from previous technology adoption studies could be applicable to the current research on digital museums. Therefore, we hypothesize that increasing a user's computer self-efficacy can potentially increase his/herPEOU for digital museums.

H1: Increasing a user's computer self-efficacy can potentially increase his/her perceived ease of use of digital museums.

2.3. The Effect of Personal Innovativeness on PU and PEOU for Digital Museums

Personal innovativeness is a person's general willingness to make changes [Hurt et al. 1977] to do things better or differently [Kirton 1976]. The degree of change can be conceptualized based on an individual's characteristics and behavior [Kleysen&Street2001]. For instance, an innovator typically thinks and acts outside existing perceptual frames when trying to solve problems [Kirton 1976]. In contrast, an adaptor feels uncomfortable veering away from existing perceptual frames.

In response to new technology adoption, individuals have a stable trait or predisposition [Rogers 1995]. Innovators and quick adopters are more willing to take risks. The majority is slower tending to lag behind. The first two categories have a higher degree of personal innovativeness than the majority. Measuring technology adoption across time without considering personal innovativeness is not accurate [Midgley & Dowling 1978; Flynn & Goldsmith 1993]. Therefore, it is more pertinent to learn about new technology adoption via personal innovativeness; that is, a person's willingness to experiment with new information technologies [Agarwal & Prasad 1998].

Personal innovativeness becomes a critical factor in understanding the adoption of digital museums because they challenge visitors with a wide variety of technologies, including 3D, databases, social media, multimedia and online images. It is understandable that a person with high personal innovativeness is more likely to find innovations of digital museums easy to use and helpful. In contrast, a person with low personal innovativeness may find digital museums hard to use and less beneficial since they are beyond his/her current frame of reference. Touring physical museums seems to be a more appealing choice to individuals with low innovativeness. Thus, we propose:

H2a: A user's personal innovativeness has positive effect on his/her perceived usefulness of digital museums

H2b: A user's personal innovativeness has positive effect his/her perceived ease of use of digital museums.

2.4. The Effect of Media Richness on PU and PEOU of Digital Museums

Media richness is the ability of a medium to produce information that can change a recipient's understanding within a specific time interval [Daft & Lengel 1984]. For instance, face-to-face meetings have a higher degree of media richness than video conferencing, followed by telephone then written documents. Media richness as a medium is a crucial element for understanding the adoption of digital museums. The primary purpose of using real-life museums is to educate users and improve their understanding of displayed objects and this remains the same for digital museums. In order to achieve their purpose, digital museums have incorporated new media that may potentially help improve their usefulness. To understand the potential adoption of different digital museum media, it is important to assess the richness of their features.

Media richness is a function of four attributes: (1) immediate feedback, (2) the number of cues and channels available, (3) language variety, and (4) information recipient focus [Daft & Lengel 1984]. Most digital museums adopt media with these four features. For instance, the Internet browser is an application essential for users to virtually tour digital museums. A user can use forward, back, or reload features to obtain immediate feedback [Kim et al. 2012]. To reduce ambiguity and enhance understanding, digital museums have used multiple social cues, such as sound, animation, graphics, video, and virtual reality. Multiple language support is another means to advance understanding of objects of interest. Social media that engage users by providing personalized information about upcoming museum events have an information recipient focus. The more difficult a topic is to understand, the higher the degree of media richness necessary to enhance a user's comprehension of it [Daft et al. 1987]. With the diversity of objects included in a digital museum, helping the public understand them via rich media is indispensable.

Vividness via multiple social cues (e.g. multimedia, gesture, voice, tone, and facial expressions) has a positive influence on the attitude toward using websites [Coyle & Thorson 2001; Wirtz et al. 2013] so digital museums adaptation of a wide variety of these social cues has the potential to help users form a more positive attitude . Some visitors use digital museums to learn how scientific revolutions make their breakthroughs. The understanding requires some analytical effort. Media with much language variety (e.g. symbol systems) have a higher performance than media with a low variety (e.g. text-based systems), particularly for analytical tasks [Lim & Benbasat 2000]. Digital museums are distinct from traditional museums in their ability to deliver personalized content to users based on differences in their age, experience, gender, bandwidth, and interest [Hong et al. 2000].

An effective digital museum needs to be user-centered and provide interactive feedback [Petridis et al. 2006]. Virtual reality is one effective medium to help users understand museum objects [Mitsumine et al. 1996;Goodall et al. 2004].Some e-businesses also find virtual reality an effective medium to showcase products and enhance understanding and awareness of their products [Kil-Soo & Young 2005]. Interactivity can be further classified into machine and human interactivities [Hoffman & Novak 1996]. Some digital museums allow users to customize the touring itinerary and environment for personal needs. Others provide fans groups on Facebook enabling the exchange of experiences. The former is machine interactivity, and the latter is human interactivity. Improving the quality of these system features has the potential of increasing attractiveness [Tseng et al. 2011] for digital museum users. Moreover, interactivity can ease the learning process for users [Dennis & Susan 1998] and increase their PU and PEOU [Straub et al. 1995]. Digital museums adopting a wide range of media (e.g. high interactivity, social cues, language diversity, and personal focus) have the potential of improving a user's PU and PEOU. Therefore, this study posits that

H3a: Media richness has positive influence on his/her perceived usefulness of digital museums

H3b: Media richness has positive influence on his/her perceived ease of use of digital museums.

2.5. The Effect of PU and PEOU on Attitude toward Using Digital Museums

PU and PEOU are two main constructs in the TAM. PU is the degree to which a user believes a particular technology has the potential of improving his/her job performance. PEOU is the degree to which a user believes a particular technology would require little effort. These two constructs are derived from the theory of reasoned action (TRA) [Fishbein & Ajzen 1975]. A user's attitude is an effective predictor of a person's intention to adopt new technologies [Davis 1989].

Scholars have applied TAM to understand the adoption of different technologies by different kinds of users. For instance, AI-Khaldi and Wallace [1999] investigated personal computer (PC) adoption by general users. Bhattacherjee [2001] tried to understand the adoption of online brokerage systems. Celik and Yilmaz [2011] studied adoption of e-shipping by consumers. We are interested in understanding the adoption of digital museums by general users. The use of these museums involves PCs and e-commerce technologies. For this reason, we assume that PU and PEOU are also important antecedents for a user's positive attitude. We therefore hypothesize that increasing PU and PEOU can help users form a more positive attitude toward using digital museums, thereby increasing the intention of actual use.

H4a: Perceived usefulness has positive influence on a user's attitude toward using digital museums.

H4b: Perceived ease of use has positive influence on a user's attitude toward using digital museums.

H5: A user's attitude toward using digital museums has a positive influence on a user's intention to use digital museums

Our literature review led us to develop an integrative model (Figure 2) to investigate digital museum adoption by adding three pertinent antecedents (e.g. computer self-efficacy, personal innovativeness, and media richness) to the existing TAM.

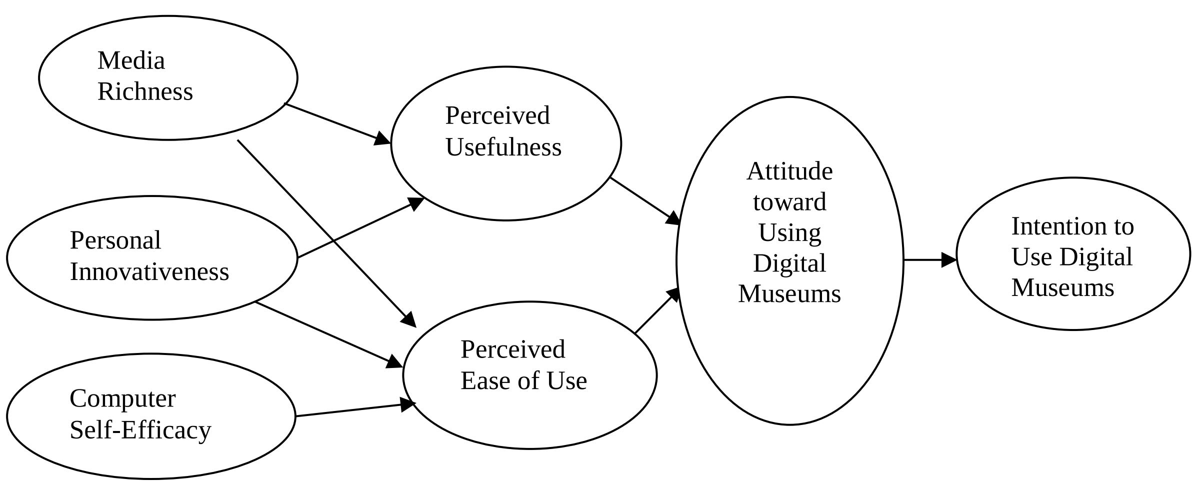


Figure 2: Proposed Research Model

3. Research Methodology

We adopted the survey method to understand the relationship between these constructs. Questions used to measure each construct were taken from published literature and modified for the context of digital museum adoption. The revision enabled us to develop a survey questionnaire to measure all constructs of the study. Table 1 lists the sources of questions and definitions for each construct.

Table 1: Operational Definitions and Measures of Constructs

Construct	**Operational Definition**	**# of Items**	**Source**
Computer Self-Efficacy	Self-efficacy for completing basic, and advanced computing skills	10	Compeau & Higgins [1995]
Personal Innovativeness	The willingness of an individual to try out any new information technologies	4	Agarwal & Prasad [1998]
Media Richness	The equivocality of the message must be matched to the medium so that uncertainty in interpretation of the content is reduced. Media richness includes the media’s capacity for immediate feedback, number of cues, channels utilized, personalization and language variety.	8	Webster & Trevino [1995]
Perceived Usefulness	The degree to which a person believes that using a particular system would enhance his/her job performance	4	Venkatesh & Davis [2000]
Perceived Ease of Use	The degree to which a person believes that using a particular system would be free from effort	4	Venkatesh & Davis [2000]
Behavioral Attitude	A person's subjective probability that he will perform some behavior	4	Taylor & Todd [1995]
Usage Intention	A user’s intention to use technology	2	Venkatesh & Davis [2000]

All questions adopted Likert’s five-point scale (1: strongly disagree; 2: disagree, 3: neutral, 4: agree; 5: strongly agree) to measure all constructs other than the computer self-efficacy, which uses Likert’s 10-point scale. A panel of experts, including two MIS professors and two museum professionals, were invited to examine the content validity of the revised questionnaire. Constructive feedback (deleting inappropriate questions, clarifying ambiguous questions) from these experts was incorporated into the second revision. A pilot test was then conducted with 20 users of digital weather museums. The questions were further improved by considering the feedback from the users of this test.

We launched a full-scale study with the users of a weather museum in Taiwan. To collect data from potential users, we collaborated with three institutes that were promoting the use of digital weather museums. A total of seven seminars in three locations were held to educate visitors about the use of the digital weather museum. We distributed 441 surveys to these visitors and asked for their cooperation. We had 327 valid responses, a 74% response rate. To ensure that the responses had a high reliability and validity, we conducted the Box Plot test to identify and exclude outliers or extreme values. This validity test reduced the number of our valid responses to 250.

3.1. Demographical Analysis

We conducted a descriptive statistical analysis and an ANOVA analysis using SPSS 11.0 software to understand the data’s integrity. Our descriptive analysis showed that 42.4% of our subjects were males and 57.6% were females. About 38.4% of our subjects were in the 31-40 age group, followed by the 41-50 age group (28.4%) and the 21-30 age group (20.4%). Most subjects (94.4%) were from the southern part of Taiwan since the survey was conducted there and the majority had a college degree (66% of subjects were college students) or above (28.4% of subjects were graduate students).

Digital museums adopt rich media (e.g. virtual reality and personal focus) that consumes bandwidth. Internet bandwidth is related to a user’s experiences (e.g. waiting time, video resolution, and animation quality) of using a digital weather museum. Consequently, a user’s adoption intention could be affected if the bandwidth is not properly controlled. To understand the potential influence of location and Internet bandwidth where the data was collected, we conducted an ANOVA analysis on the differences between PU, PEOU, attitude, and usage intention in the varying locations. Table 2 shows that F values in these constructs are not significantly different from each other.

This finding indicates that bandwidth difference has an insignificant influence on the collected data, and that data collected from different locations can be treated as the same.

Table 2: ANOVA Analysis Results

Constructs	Locations		Internet Bandwidth	
	F Value	p Value	F Value	p Value
Perceived Usefulness	0.425	0.655	0.054	0.817
Perceived Ease of Use	0.044	0.957	0.024	0.877
Attitude	0.671	0.512	0.096	0.757
Usage Intention	0.887	0.413	1.478	0.225

3.2. Reliability and Validity Analyses

It is important to ensure that the survey questions used to measure each construct have acceptable validity and reliability before conducting data analysis to validate our hypothesized relationships. To ensure a high content validity, we invited information system experts and the management of digital museums to review our initial draft and provide constructive feedback. We made changes to our original questions based on this feedback. A pilot test was conducted with college students to ensure that the questions were easy to understand and not ambiguous. After achieving content validity, we conducted KMO and Bartlett's tests and the findings (Table 3) indicated that common factors between constructs existed (KMO MSA values > 0.5; p values >0.01) and warranted a factor analysis [Hair et al. 1998]. We then used the extraction method of maximum likelihood and varimax rotation to conduct the factor analysis to check the validity of the survey questions used to measure each construct. The goal was to verify whether the questions used to measure one construct had low correlations with the questions used to measure another construct since questions used to measure the same construct should have a high correlation. Table 4 shows that factor loading values for all constructs exceed the threshold value of 0.35, andCronbach's α values exceed the threshold value of 0.80 [Hair et al. 1998]. This finding indicates that the reliability of the survey questions used to measure each construct was high. Our standardized factor loading values also showed that all questions, other than ATT3 (loading value of 0.492) and ATT4 (0.548), used to measure attitude, exceeded the threshold value of 0.60 [Hair et al. 1998]. Because these two items had a low validity, they were excluded from out path analysis.

Table 3: KMO and Bartlett's Test of Sphericity

Constructs	KMO MSA	Approx. Chi-Square	Bartlett's Test of Sphericity d.f.	Sig.
Computer Self-Efficacy Personal Innovativeness Media Richness	0.911	4818.504	231	0.000
Perceived Usefulness Perceived Ease of Use Behavioral Attitude Usage Intention	0.929	2755.116	91	0.000

Table 4: Results of Reliability and Validity Analyses

Item	Factor Loading Value	Cronbach's α Value
Computer Self-Efficacy (CSE)		
CSE1: I feel confident using the digital weather museum (DWM) without any help	0.753	0.960
CSE2: I feel confident using the DWM even though I did not use similar systems	0.792	
CSE3: I feel confident using the DWM with only the instructional manual	0.843	
CSE4: I feel confident using the DWM after seeing someone else using it	0.870	
CSE5: I feel confident using the DWM if I have someone to assist me when help is needed	0.812	
CSE6: I feel confident using the DWM if someone can help me the first time I use it	0.786	

CSE7: I feel confident using the DWM if I have enough time to experiment using it	0.881	
CSE8: I feel confident using the DWM if the online help function is available	0.877	
CSE9: I feel confident using the DWM if someone can give me a demo	0.872	
CSE10: I feel confident using the DWM if I ever used a similar system	0.881	
Personal Innovativeness (PI)		
PI1: If I heard about a new information technology, I would look for ways to experiment with it.	0.813	0.842
PI2: Among my peers, I am usually the first to try out new information technologies.	0.849	
PI3: In general, I am hesitant to try out new information technologies*	0.834	
Media Richness (MR)		
MR1: I can use the DWM smoothly	0.659	0.912
MR2: The DWM provides not only static information, but also dynamic information (e.g. audio, video, and animation)	0.753	
MR3: The DWM offers options of presenting information in different formats (e.g. different resolutions, bandwidths, and hardware specs) according to personal needs	0.737	
MR4: Videos and animations in the DWM offer rich and diversified instructional methods	0.829	
MR5: The DWM can provide me instant feedback upon my requests	0.716	
MR6: The DWM presents information about objects in different formats (e.g. text, picture, video, audio, animation, and 3D virtual environment)	0.804	
MR7: The DWM provides accurate information in pictures, texts, and numbers	0.811	
MR8: The DWM can provide customized information (e.g. instruction with different difficulty levels)	0.806	
Perceived Usefulness (PU)		
PU1: Using the DWM would enhance my learning effectiveness	0.771	0.917
PU2: Using the DWM would increase my learning productivity	0.813	
PU3: Using the DWM would increase my learning efficiency	0.731	
PU4: I find the DWM a useful way of learning	0.743	
Perceived Ease-of-Use (PEOU)		
PEOU1: My interaction with the DWM is clear and understandable	0.802	0.881
PEOU2: I believe it would be easy to get the DWM to do what I want it to do	0.824	
PEOU3: Overall, I believe the DWM would be easy to use	0.709	
PEOU4: Learning to use the DWM would be easy for me	0.609	
Attitude (ATT)		
ATT1: Using the DWM is a good method	0.753	0.889
ATT2: Using the DWM is a wise idea	0.825	
ATT3: I like the experience of using the DWM	0.492	
ATT4: Using the DWM would be pleasant	0.548	
Usage Intention (UI)		
UI1: I intend to increase my use of the DWM in the future	0.713	0.856
UI2: For future work I would use the DWM	0.818	

*reverse scaled item

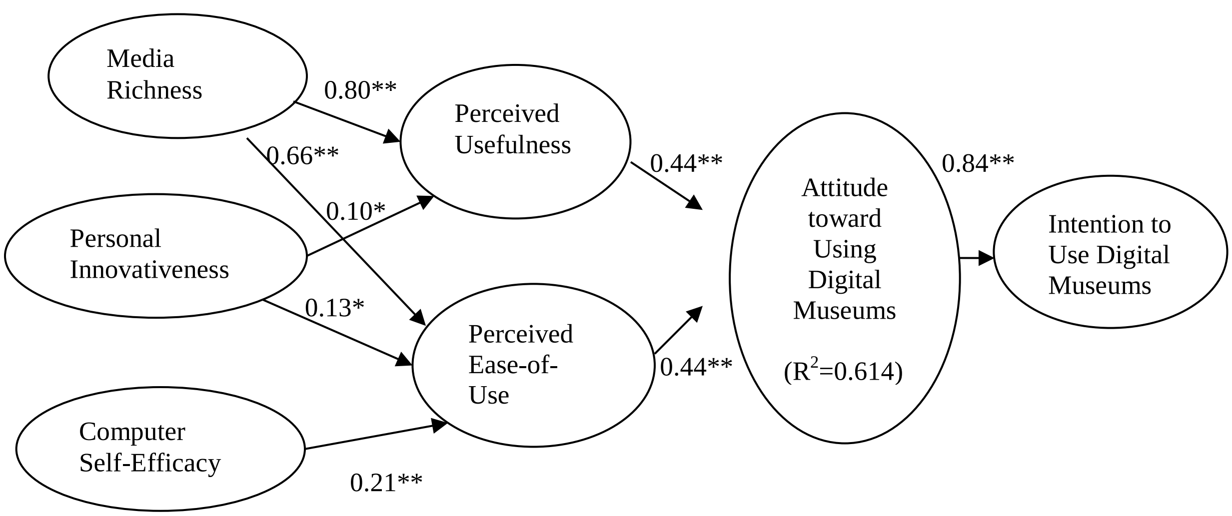
After meeting all the reliability and validity requirements, we entered our data into the path analysis using the structural equation method. AMOS 7.0 was adopted to help analyze the collected data. Table 5 summarizes the model fit indices. The chi-square/d.f. index value is below the recommended threshold value (3.00), indicating that our model fitted perfectly in the population. The values of goodness of fit indices (i.e. GFI, AGFI, NFI, IFI, CFI and RMSEA) exceeded their recommended cut-off values [Browne & Cudeck 1993; Hair et al. 1998]. These indices affirm that the overall fit of the research model was satisfactory and warranted a path analysis to test our proposed hypotheses.

Table 5: Model Fit Indices of the Proposed Research Model

Fit Index	Recommended Threshold Values	Fit Value of Our Research Model
Chi-Square/d.f.	<3.00	1.80
GFI (Goodness of Fit Index)	>0.80	0.84
AGFI (Adjusted Goodness of Fit Index)	>0.80	0.81
NFI (Normal Fit Index)	>0.90	0.90
IFI(Incremental Fit Index)	>0.90	0.95
CFI (Comparative Fit Index)	>0.90	0.95
RMSEA (Root Mean Square Error of Approximation)	<0.08	0.05

Figure 3 shows the coefficients of all paths and the standard regression weights of all dependent variables of computer self-efficacy, personal innovativeness, and media richness. Our path analysis results showed that intention to use digital museums (R^2=0.71) had the highest explanatory power for our proposed research model, followed by PU (R^2=0.70), PEOU (R^2=0.70) and attitude (toward using digital museums) (R^2=0.64).

A closer examination of standardized path coefficients and their significance level showed that all constructs had a significant influence on their dependent variable as hypothesized. Computer self-efficacy had a positive influence on PEOU (p=0.000 < 0.01). Hypothesis 1 is supported. Personal innovativeness likewise had positive influence on PU (p=0.03 < 0.05) and PEOU also (p=0.01 < 0.05). Hypotheses 2a and 2b are supported. Media richness had a positive influence on both PU (p=0.000 < 0.01) and PEOU (p=0.000 < 0.01).Hypotheses 3a and 3b are supported. PU (p=0.000 < 0.01) and PEOU (p=0.000 < 0.01) also had a positive influence on the user's attitude toward using digital museums, thereby having a positive influence on the intention to use digital museums (p=0.000 < 0.01). Hypotheses 4 and 5 are supported.



Note: * p < 0.05; ** p < 0.01

Figure 3: SEM Analysis Results

4. Discussion

This study has helped us understand that computer self-efficacy, personal innovativeness, and media richness influence the adoption of digital museums. Our findings show that these three constructs play an important role in increasing a user's PEOU for digital museum adoption. Moreover, media richness also increasesPU.

Our findings confirm that the effectiveness of ontology such as rich media can increase a user's PUandPEOU. The Library of the University of North Carolina at Chapel Hill researched a domain-specific ontology to facilitate access to information concerning digital museums as a teaching tool. Many social studies teachers in this study found that the ontology design is helpful and easy to use because it not only supports the information requirements but also enhances information accessibility [Pattuelli 2011]. The ontology has the important feature of media richness; that is, user-centered information.

Computer self-efficacy and personal innovativeness are two important prerequisites for professionals to consider when encouraging users to adopt these museums which have emerged from technological innovations such as the web, the digital camera, barcode, secure communication technology, virtual reality, and social media. Some amateur historians are active contributors to an Internet encyclopedia developed by the Chippewa Valley Museum [Swedien 2011]. These contributors may have higher computer self-efficacy and personal innovativeness than those who choose to play more passive roles.

Increasing PU for digital museums will help users form a more positive attitude toward using them. Some governments are promoting their use. The Museum and Library Services funded The Carnegie Library of Pittsburgh (http://www.carnegielibrary.org), Pennsylvania, with their project “Legacy of Iron and Steel” which digitalized parts of their museum. The goal of this project was to document 400,000 pages related to historical roles in the production of industrial metals in the region. Making these important documents available was crucial for the adoption of digital museums because they will be found extremely useful for educational purposes.

Making digital museums easy to use is another approach to help users effectively form a more positive attitude and intention toward using their virtual services. New York’s Guggenheim Museum uses original interactive artwork to attract online visitors (e.g. touch screen technology) [Macedonia 2003], and help users engage with artifacts [Zimmer & Jefferies 2007].

4.1. Academic Contributions

TAM is an established model investigating general technology adoption. Digital museums incorporate many novel technologies and warrant an investigation from the perspective of TAM. Unlike the traditional museum, digital museum adoption necessitates general users having some degree of computer self-efficacy and personal innovativeness. Since, the main purpose of digital museums is to educate and inspire users so that they can advance their understanding of interesting artifacts the media richness theory affirms that it is effective in helping learners understand more complex subjects. This study makes its contribution by adding media richness to the existing TAM. An extended TAM incorporating computer self-efficacy, personal innovativeness, and media richness provides a better understanding of improving digital museum adoption from the individual perspective rather than the technological perspective.

4.2. Practical Contributions

The operation of traditional museums is losing its viability because of the economic downturn, the decreased number of attendees, fewer donor supporters, and increased competition for the spare time of the public. Digital museums are a new way to increase exposure, educate the public, receive donor support, inspire users, and help the local economy. For instance, Maryland Federation of Art is a small gallery, yet has a high exposure via the web and virtual reality technologies. The Costume Institute of Metropolitan Museum of Art is actively using the Internet to encourage the process of learning about historic costume collections, and to inspire fashion designers and students [Sauro 2009].

Advanced new technology with its high degree of media richness is redefining the museum institution and museum profession [Svilicic 2010] requiring careful consideration of a visitor’s personal dispositions (computer self-efficacy and personal innovativeness). Lack of consideration of these essential elements/factors can render digital museums useless. Digitalizing museum artifacts is a daunting task and requires careful handling of fragile and historical artifacts. An important task for museums is to develop or adopt a standard digitization methodology to incorporate evolving technologies into their operation [Surendran et al. 2009]. When doing so, museum professionals need to take users’ computer self-efficacy and personal innovativeness into account because they are less motivated by complicated system features [Marty 2011]. A digital museum replaces the traditional pre-determined guided tour with a personalized tour via mobile and micro bloging technology [Hsu & Liao 2011]. The ability of adding rich media into the display can excite not only users with high computer self-efficacy and personal innovativeness, but also lower the learning curve for less able ones.

Many artifacts in the traditional museums today are facing spatial limitations and scarce resources. The traditional lesson plans that public school teachers used when taking a field trip to a museum become less feasible. Many teachers are resorting to digital museums to create and deliver a broad array of useful teaching resources [Wetterlund 2008], such as Web 2.0 technology [Srinivasan et al. 2009a], hyperlinks to other relevant sites, FAQs, online tours, and discussion group links. Some museums have been adopting personal digital collections system to help users create simple collections of objects and images for viewing convenience [Marty 2011].

The innovative use of digital museums can potentially resolve the dilemma of increasing the number of visitors with limited physical space and financial shortage that many traditional museums are facing today. Although digital museums have many benefits, they cannot replace the traditional museums. A study conducting a content analysis of

60 costume and textile collection web sites revealed that digital museums stimulate many users to visit the physical museums in order to appreciate all the specific features of actual artifacts [Saiki & Robbins 2008]. More importantly, digital museums are becoming a new platform to foster the dialogic communication between museums and their publics, and continuously improve the quality of their public services [Capriotti & PardoKuklinski 2012].

5. Limitations and Future Research

The digital weather museum is a niche museum appealing to a small segment of users. Generalizing the findings of this study to other kinds of digital museums requires careful consideration. The majority of subjects in this study had a college degree and years of experience using different information technologies. Since the target user of digital museums is the public, future research could conduct a survey within the general public instead of using workshops to attract users. We did not compare digital weather museums with other types of museums. The relationships between constructs may vary with different kinds of museums. Additional research to compare different museums based on our research framework could provide insights into other constructs pertinent to the study of digital museums.

Now with the proliferation of digital museums, researchers can direct their attention from technology adoption to the use of them for educational purposes. Media richness has a positive effective on both PU and PEOU. Future research could consider the use of different media with varying degrees of richness to improve the understanding of the public or students in regard to artifacts displayed in digital museums.

6. Conclusion

Emerging information technologies are indispensable to digital museums. However, technological success does not guarantee their operational success. This study offers a fresh understanding from the perspective of general users. The literature review led us to develop an extended TAM that incorporated three new constructs pertinent to the understanding of digital museum adoption: computer self-efficacy, personal innovativeness, and media richness. A proper consideration of these three constructs can increase a user's PU and PEOU, thereby forming a more positive attitude and intention toward the use of them. With their increased acceptance, the grass root movement will accelerate allowing more users to play active roles in interpreting historical artifacts and to influence the representation of them in museums. The success of digital museum adoption can enrich the overall museum experience for the public.

REFERENCES

Agarwal, R. and J. Prasad, "A Conceptual and Operational Definition of Personal Innovativeness in the Domain of Information Technology,"*Information Systems Research*, Vol. 9, No. 2:204-215, 1998.

Albanese, M., A. Chianese,A. d'Acierno, V. Moscato, and A. Picariello, "A Multimedia Recommender Integrating Object Features and User Behavior,"*Multimedia Tools and Applications*, Vol. 50, No. 3:563-585, 2010.

Aron, J.,"Ancient Buildings Brought to Life from Historical Maps,"*New Scientist*, Vol. 209, No. 2798:22, 2011.

Arvanitis, K., "What is the Single Most Important Function of Museums," Retrieved April 12, 2011, from http://digitalheritage.wordpress.com/2007/11/22/what-is-the-single-most-important-function-of-museums/, 2007.

AI-Khaldi, M.A. and R.S.O. Wallace, "The Influence of Attitude on Personal Computer Utilization among Knowledge Workers: The Case of Saudi Arabia,"*Information and Management*, Vol. 36, No. 4:185-204, 1999.

Bagozzi, R. P., F.D. Davis, F. D., and P. R. Warshaw, "Development and test of a theory of technological learning and usage," *Human Relations*, 45(7): 660–686, 1992.

Bhattacherjee, A.,"Understanding Information Systems Continuance: An Expectation-Confirmation Model,"*MIS Quarterly*, Vol. 25, No. 3:351-370, 2001.

Bandura, A.,*Social foundations of thought and action: A social cognitive theory*, NJ, Englewood Cliffs: Prentice-Hall, 1986.

Bandura, A., Self-efficacy. In V.S. Ramachaudran (Ed.), Encyclopedia of Human Behavior, 4, 71-81, New York: Academic Press, 1994.

Bonis, B., J. Stamos, S. Vosinakis, I. Andreou, and T. Panayiotopoulos, "A Platform for Virtual Museums with Personalized Content,"*Multimedia Tools and Applications*, Vol. 42, No. 2:139-159, 2009.

Browne, M.W.and R. Cudeck, "Alternative Ways of Assessing Model Fit," in, Bollen, K. and J.S. Long, (eds.), Testing Structural Equation Models, CA, Newbury Park: Sage Publications, 136-162, 1993.

Capriotti, P. andH.PardoKuklinski, "Assessing dialogic communication through the Internet in Spanish museums,"*Public Relations Review*,Vol. 38, No. 4:619-626, 2012.

Celik, H. E. and V. Yilmaz, "Extending the Technology Acceptance Model for Adoption of E-Shopping by

Consumers in Turkey," *Journal Of Electronic Commerce Research*, Vol. 12, No. 2:152-164, 2011.

Compeau, D.R. and C.A. Higgins, "Computer Self-Efficacy: Development of a Measure and Initial Test,"*MIS Quarterly*, Vol. 19, No. 2:189-211, 1995.

Coyle, J.R. and E. Thorson,"The Effects of Progressive Levels of Interactivity and Vividness in Web Marketing Sites,"*Journal of Advertising*, Vol. 30, No. 3:65-77, 2001.

Daft, R.L. and R.H. Lengel, "Information richness: A new approach to managerial behavior and organizational design," In: Cummings, L.L. and Staw, B.M. (Eds.), Research in Organizational Behavior 6, (191-233). Homewood, IL: JAI Press, 1984.

Daft, R.L., R.H. Lengel, and L. Trevino,"Message Equivocality, Media Selection, and Manager Performance,"*MIS Quarterly,* Vol. 11, No. 3:355-366, 1987.

Davis, F. D.,"Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology,"*MIS Quarterly,* Vol. 13, No. 3:319-339, 1989.

Dennis, R.A. and T.K. Susan, "Testing Media Richness Theory in the New Media: The Effects of Cues, Feedback, and Task Equivocality,"*Information Systems Research,* Vol. 9, No. 3:256-274, 1998.

Fishbein, M. and I. Ajzen, Belief, attitude, intention, and behavior: An introduction to theory and research. Reading, MA: Addison-Wesley, 1975.

Flatley, K., "View/Web Site: Smithsonian Wired," in Wall Street Journal, 1998.

Flynn, L.R. and R.E. Goldsmith, "A Validation of the Goldsmith and Hofacker Innovativeness Scale,"*Educational and Psychological Measurement*, Vol. 53:1105-1116, 1993.

Geber, K.,"Participation as a Model the Canadian Heritage Information Network,"*Interactive Technologies and Sociotechnical Systems Lecture Notes in Computer Science*, Vol. 4270:396-398, 2006.

Goodall, S., P.H. Lewis, K. Martinez, P.A.S. Sinclair, F. Giorgini, M.J. Addis, M.J. Boniface, C. Lahanier, and J. Stevenson,"SCULPTEUR: Multimedia Retrieval for Museums. Image and Video Retrieval,"*Proceedings lecture notes in Computer Science*, Vol. 3115:638-646, 2004.

Goodison, D., "Google Fives $1M Grant to Museum of Science," McClatchy – Tribune Business News, April 6, 2011.

Hair, J. F., R.E. Anderson, R.L. Tatham, and W.C. Black,*Multivariate Data Analysis*, NJ, Englewood Cliffs:Prentice-Hall, 1998.

Hoffman, D.L. and T.P. Novak, "Marketing in Hypermedia Computer-Mediated Environments: Conceptual Foundations,"*Journal of Marketing*, Vol. 60, No. 3:50-68, 1996.

Hong, J.S., H.Y. Chen, and J. Hsiang, "A Digital Museum of Taiwanese Butterflies,"*Paper presented at the 5th ACM Conference on ACM 2000 Digital Libraries*, 260-261, 2000.

Hsu, H.H., and H.T. Liao, "A Mobile RFID-Based Tour System with Instant Microblogging,"*Journal of Computer and System Sciences*, Vol. 77, No. 4:720-727, 2011.

Hurt, H., K. Joseph, and C. Cook, "Scales for the Measurement of Innovativeness,"*Human Communication Research*, Vol. 4:58-65, 1977.

Igbaria, M. and J. Iivari, "The Effect of Self-Efficacy on Computer Usage,"*Omega*, Vol. 23, No. 6:587-605, 1995.

Kil-Soo, S. and E.L. Young, "The Effect of Virtual Reality on Consumer Learning: An Empirical Investigation,"*MIS Quarterly*, Vol. 29, No. 4:673-697, 2005.

Kim, C., M-H., Jin, J. Kim, and N. Shin, "User Perception of the Quality, Value, and Utility of User-Generated Content," *Journal of Electronic Commerce Research*, Vol. 13, No. 4:305-319, 2012.

Kirton, M.,"Adaptors and Innovators: A Description and Measure,"*Journal of Applied Psychology*, Vol. 61:622-629, 1976.

Kleysen, R.F. and C.T. Street, "Toward a Multi-Dimensional Measure of Individual Innovative Behavior,"*Journal of Intellectual Capital*, Vol. 2, No. 3:284-296, 2001.

Koening, M.,"More than Museums,"*Information Outlook*, Vol. 1, No. 12:15-16, 1997.

Lim, K.H., and I. Benbasat, "The Effect of Multimedia on Perceived Equivocality and Perceived Usefulness of Information Systems,"*MIS Quarterly*, Vol. 42, No. 3:449-471, 2000.

Macedonia, M.,"Revitalizing Museums with Digital Technology,"*Computer*, Vol. 36, No. 2:94-96, 2003.

Marakas, G.M., M.Y. Yi, and R.D. Johnson, "The Multilevel and Multifaced Character of Computer Self-Efficacy: Toward Clarification of the Construct and an Integrative Framework for Research,"*Information System Research*, Vol. 9, No. 2:126-163, 1998.

Marty, P.F.,"My Lost Museum: User Expectation and Motivation for Creating Personal DigitalCollections on Museum Websites,"*Library & Information Science Research*,Vol. 33, No. 3:211-219, 2011.

Midgley, D.F. and G.R. Dowling,"Innovativeness: The Concept and Its Measurement,"*Consumer Research*, Vol. 4:229-242, 1978.

Mitsumine, H., H. Noguchi, K. Enami, Y.Ninomiya, Y.Yamanoue, S. Yano, A. Hanazato, and M. Okui, "Virtual Museum - 3D Fine Art Appreciation System,"*IEEE Transactions on Broadcasting*, Vol. 42, No. 3:200-207, 1996.

Pattuelli, M.C.,"Modeling a Domain Ontology for Cultural Heritage Resources: A User-Centered Approach,"*Journal of the American Society for Information Science and Technology*, Vol. 62, No. 2:314-342, 2011.

Rockweiler, N. and M. Weinhold, "Dimensions of the Virtualization of Museums,"*Zeitschrift Fur Padagogik*,Vol. 5, No. 6:786-796, 2005.

Rogers, E.,*Diffusion of Innovations*. (4th ed.). New York, NY: The Free Press, 1995.

Saiki, D. and A. Robbins, "Trends in Information Categories on Costume and Textile Collection Web Sites,"*Electronic Library*, Vol. 26, No. 6:821-832, 2008.

Sauro, C.,"Digitized Historic Costume Collections: Inspiring the Future While Preserving the Past,"*Journal of the American Society for Information Science and Technology*, Vol. 60, No. 9:1939-1941, 2009.

Srinivasan, R., R. Boast, J. Furner, and K.M. Becvar, "Perspective: Digital Museums and Diverse Cultural Knowledge: Moving Past the Traditional Catalog,"*The Information Society*, Vol. 25:265-278, 2009a.

Srinivasan R., R. Boast, K.M. Becvar, and J. Furner, "Blobgects: Digital Museum Catalogs and Diverse User Communities,"*Journal of the American Society for Information Science and Technology*, Vol. 60, No. 4:666-678, 2009b.

Srinivasan, R., K.M. Becvar, R. Boast, andJ. Enote, "Diverse Knowledge and Contact Zones within the Digital Museum, Science,"*Technology & Human Values*, Vol. 35, No. 5:735-768, 2010.

Straub, D., M. Limayem, and E. Karahanna, "Measuring System Usage: Implications for IS Theory Testing,"*Management Science*, Vol. 41, No. 8:1328-1342, 1995.

Surendran, N.K., X.W. Wu, and O. Stead, "Contemporary Technologies for 3D Digitization of Maori and Pacific Island Artifacts,"*International Journal of Imaging Systems and Technology*, Vol. 19, No. 3:244-259, 2009.

Svilicic, N., "Creation and Typology Definition of the Museum on the Internet,"*Collegium Antropologicum*, Vol. 34, No. 2:587-594, 2010.

Swedien, J.,"Museum Launches Online Encyclopedia of Chippewa Valley History," McClatchy – Tribune Business News, April 11, 2011.

Taylor, S. and P.A. Todd, "Understanding Information Technology Usage: A Test of Competing Models,"*Information Systems Research*, Vol. 6, No. 2:144-176, 1995.

Tseng, M., R. Lin, and H. Chen, "Evaluating the Effectiveness of E-learning System in Uncertainty,"*Industrial Management & Data Systems*,Vol. 111, No. 6:869-889, 2011.

Venkatesh, V. and F.D. Davis, "A Model of the Antecedents of Perceived Ease of Use: Development and Test,"*Decision Sciences*, Vol. 27, No. 3:451-481, 1996.

Venkatesh, V. and F.D. Davis, "A Theoretical Extension of the Technology Acceptance Model: Four Longitudinal Field Studies,"*Management Science*, Vol. 46, No. 2:186-204, 2000.

Webster, J. and L.K. Trevino, "Rational and Social Theories as Complementary Explanations of Communication Media Choices: Two Policy Capturing Studies,"*Academy of Management Journal*, Vol. 38, No. 6:1544-1572, 1995.

Wetterlund, K.,"Flipping the Field Trip: Bring the Art Museum to the Classroom,"*Theory into Practice*, Vol. 47, No. 2:110-117, 2008.

Winslow, T.,"A Virtual Success: Maryland Federation of Art exhibit on Internet Tour," in: The Capital, 2011.

Wirtz, B. W., R. Piehler, and S. Ullrich, "Determinants of Social Media Website Attractiveness," *Journal of Electronic Commerce Research*, Vol. 14, No. 1:11-33, 2013.

Zimmer, R. and J. Jefferies, "Accessing Material Art through Technologies of Mediation and Immediation,"*Futures*,Vol. 39, No. 10:1178-1190, 2007.