Touchscreen Kiosks in Museums

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What factors affect people's decisions on using kiosks in museums

The information provided to museum visitors is a key component in improving their involvement and thus their attendance. Therefore, technologies are considered a valuable resource for catching visitor attention and stimulating their involvement [122]. 51% of museums and other cultural institutions participating in the 2013 Dosdoce.com study [36] indicated that they were contemplating the use of touchscreens in their exhibition halls, and 65.6% of museums and other cultural institutions in this study claimed that their main priority is to *attract new audiences* to their centres via new technologies.

Museum visitors frequently report being more engaged with the museum's exhibit when they have opportunities for interaction [98]. Research on visitor learning in museums demonstrates that interactives promote engagement, understanding, and recall of exhibits and their content [6]. Rather than the interactives providing a substitute experience, interactives encourage visitors to explore and engage with the rest of the museum exhibits [104]; museum visitors who used interactives also spend more time on observing non-interactive objects than those visitors who does not use interactives [37]. (However, there are also contrasting observations when virtual objects on the kiosk screen became the object of interest, rather than the actual artifacts, but in this case the visitors observed were mostly younger children [18].) Interactive experiences can even significantly change visitors' perception of museums as a whole type of cultural institutions so they do not perceive them as "old" and "dusty" places anymore [45][79]. Therefore, introduction of kiosks can help museums in their permanent efforts to attract younger population which still perceives a museum as an inappropriate place for spending their leisure time. Research by Owen, Buhalis & Pletinckx [112] showed that the younger the respondent the more technology influenced their decision to visit a cultural heritage institution. Falk & Dierking [44] state that "media-rich exhibitions represent a strategy for creating museum-comfort today for tomorrow's museum-going public".

Anyway, kiosks serve as a *secondary* means of museum exploration. Observations of visitors' behavior in museums show that interactive media use is highly self-selected: some visitors use interactives while others ignore them completely [44][93]. The research on reasons behind the observed visitors' attitudes to use kiosks was mostly concerned with their demographics such as age and gender. In particular, studies on gender and use of museum interactives showed inconsistent results about gender differences in kiosk use: some studies revealed that users of kiosks were mostly male whereas other researches showed that users were predominantly female [58]. It was also shown that younger visitors, and children in particular, tend to use kiosks more frequently than older population [18][19][28][48][80]. Unfortunately, the existing research was focused on superficial characteristics of users. Summarizing the research to date it seems the main problem is that we still have no knowledge about intrinsic motivation of museum visitors behind their use or non-use of kiosks.

Visitors to *science* museums expect to find some type of media technology at a museum and they often are actively seeking out interactivity [58]. However, Mylonakis & Kendristakis study [106] of a *history* museum visitors' expectations about the museum services showed that only a small percent of visitors described a kiosk as an essential or very important facility that the museum should have (at the same time, the museum presence on the web was evaluated as

much more important). Falk ea [45] comparative study of visitors' perceptions of interactives in two different contexts, a museum and a science center, generally supports these findings.

Economou [40] classified different cases of kiosk use in museums in order to meet various visitors' needs during their on-site visit (Table 1).

Table 1. Different types of kiosk use in museums

Kiosk use	Description
Conceptual pre-organizers and museum directories	Kiosks are positioned near the museum entrance and at key locations within the museum to convey introductory information helping the visitors to familiarize themselves with the museum concepts and offering information about what is on display at the museum and the location of exhibits and facilities. The kiosk application may also include practical information to assist orientation in the museum and planning the visit. Kiosks installed near the entrance to the exhibition can provide information about the different paths visitors can follow through a museum depending on their interests and planned time of the visit, as well as recommendations for visitors with children.
Advanced electronic labeling system for museum specimens	This allows museum curators to keep minimal information near the specimens inside the museum cases thus unloading the cases from interpretive material which can interfere with viewing the specimens. The kiosk screen usually includes a digital photograph or a graphic scheme of the case with the specimens displayed as touch-sensitive areas. When touching on an active area, the user can see the textual and multimedia information about an object at different levels, starting from the basic object label and offering the possibility to dive deeper according to the visitor's interests.
Basic background information about the exhibition themes and their general context	In this case kiosks are used to offer information not specifically tied to the objects on display: e. g. information presented in a kiosk can focus on the artist whose works are on show, present an artistic movement or historic period, or explain peculiarities of the culture which produced specimen in the exhibition.
Reference point after visiting part of the exhibition and before continuing the visit	Kiosks are placed in an adjacent space after an exhibition gallery in order to provide more in-depth information to satisfy the curiosity that the visited exhibits might arouse. Kiosks act as a reference system allowing more focused and longer interactions without disrupting the visitors' flow in the gallery or help with comparisons of objects from the collections not on display, thus improving access to all the objects in the museum collection.
Post-visit resource	Kiosks can provide takeaways in the form of a web link to digital content that can be sent to a visitor's email or a scannable QR-code to access a mobile app to continue the exhibition experience after leaving the museum's physical space.

Interactives in museums can allow visitors to obtain personalized recommendations, watch videos, search for specimens, delve into details, view related images or texts, scan QR codes on a screen to obtain more information, download museum's mobile app or purchase a digital version of the museum catalogue, share the experience with other visitors etc [36].

Although meeting the visitor needs is a key factor in successful kiosk implementation in museums, there are other important factors in regard to lowering the barrier to engaging a user into the *initial* interaction with the kiosk [2][19][54][56][129]:

- kiosks should be appropriately positioned at the strategic points within the museum rooms and integrated into exhibition context (see example in Figure 1);
- kiosks should have an attention-grabbing start screen;
- the start screen should present clear signs of device interactivity so visitors could not perceive it as a non-interactive TV or a digital signage screen.
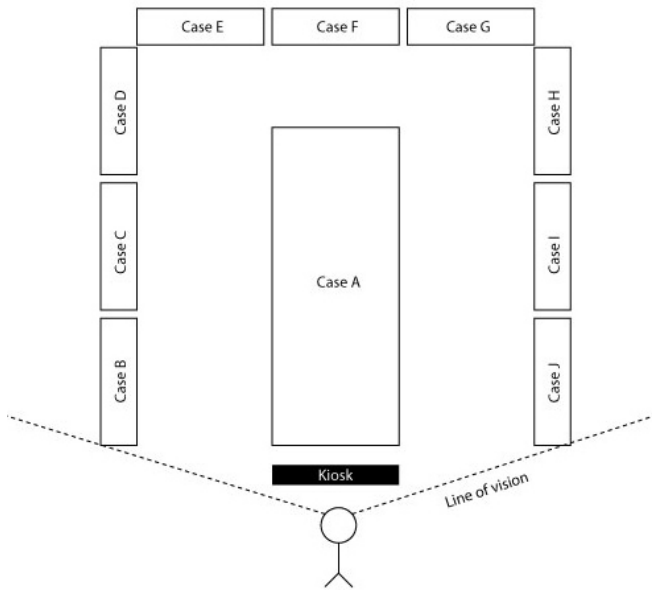
Figure 1. Example of kiosk placement within a particular museum exhibition (from [93])

Sandifer's research [128] aimed to determine characteristics of interactives that are effective in attracting and holding the attention of visitors in a science museum. Regression analysis of four characteristics examined (technological novelty, user-centeredness, sensory stimulation and open-endedness) revealed that only two of these characteristics, technological novelty and open-endedness (by this term, the author means a possibility to achieve multiple visitor-set goals and possibility for one goal to be achieved in multiple ways), have positive correlations with the amount of time spent by visitors at interactive exhibits. The generalizability of these findings to the non-science museums (taking into account that science museums attract visitors exactly by expected technological novelty of their exhibits) and their applicability to kiosks (as definitely not a novel technology) in particular are unclear.

Adams & Moussouri [3] list the key factors that visitors perceive as successful interactive experiences: (1) multi-sensory, multi-mode dialogue, exploration, and discovery; (2) cultural connections (fitting within the visitors' culture); (3) empowerment (facilitating visitors in the construction of their own experience; accessibility issues); (4) uniqueness (showing something extraordinary or showing the ordinary from an extraordinary perspective); and (5) construction of meaning (linking objects to personal experience; facilitating a rich meaning-making process; altering the visitor's conception of the art object).

Other characteristics of interactive exhibits that influence the engagement of visitors into interaction with digital media are the physical context in which the media is experienced (for example, by providing a space where a visitor can spend some time without impeding other visitors' experiences) and taking into account visitors' time budgets (for example, by presenting information in a leveled manner allowing time-constrained visitors to get the main points and offering others to access more in-depth material) [44].

In order to work effectively, kiosks require careful positioning according to the visitors' flow in the museum which requires systematic planning and evaluation to avoid situations when kiosks remain almost permanently unattended or when there is a queue of visitors wanting to use the device [40][56]. If a kiosk is placed in a busy corridor, with no space set aside for working with it, visitors will feel uncomfortable and fewer visitors will use these devices and their interactions will be shorter [44].

Summarizing the existing research on this topic it can be concluded that it is still very little known about both intrinsic motivation of visitors to use museum interactives and particular characteristics of interactives that engage visitors into interaction with them.

Types of services that people seek from using kiosks in museums

Booth's review of a *science* museum visitor information requirements [15] showed that:

- A *general visitor* requires information about opening times, the museum's facilities, what is on, important exhibits and navigation aids.
- Over and above this, an *educational visitor* requires more detailed information to plan visits as well as project-based information.
- A *specialist visitor* needs detailed information concerning the museum's collections, which includes access to the museum's expertise, and links to other sources of information such as resources in other museums.

All visitors need to be able to orientate themselves in advance of a visit in relation to the museum and its collections in order to plan a visit and locate their primary objectives and, therefore, on-line access is needed. Specialist visitors also need on-line access to detailed information about the collections. Once inside the museum, visitors need general information and orientation and navigation systems inside the entrance, backed up by collections information and orientation and navigation in the galleries. Specialist visitors require access to a resource/study centre [15].

The results of a study of museums [36] revealed a highly intensive use of technology during the discovery stage, a diminished use of tools during the visit to the physical installations of the corresponding institutions (mainly focused on the use of certain technologies for the purpose of enriching the visit), and a low use of technologies to exchange experiences after the visit. Probable implication from this study is that museums should pay more attention to the visitors' needs to experience sharing during their visit to museum. Naturally, kiosks can play an important role in this regard.

Based on the interviews, questionnaires and behavior observation of museum visitors Katre & Sarnaik [76] suggested a list of cognitive needs of museum visitors which could guide the development of kiosk applications (Table 2).

Although this study covered all age groups of museum visitors, authors also mentioned that when conducting contextual interviews they were mostly interested in younger population (aged 15 to 30 years). This might influence some design recommendations proposed by the authors, in particular, suggestions about presentation of information in small chunks and visualization of a visitor using the artefacts. In general, the proposed design recommendations look reasonable and are in compliance with other research findings, but they should be followed with care. For example, Falk & Dierking [44] suggest presentation of information at multiple levels to satisfy both time-constrained visitors and visitors who are ready to invest an extended time in working with digital interactives if they are interested in the material being presented or are fascinated by the technology.

DiPaola & Akai [35] prepared a list of design issues and suggestions to support the use of multimedia interactives in museum exhibits in a way that enhances the visitor experience and promotes the educational content: (1) effective use of technology, (2) limited contact time, (3) high traffic/use, (4) visitors travel in groups, (5) need to generate repeat visits, (6) exhibits must work without supervision, (7) present educational content in an engaging and accessible manner.

Unfortunately, the existing research literature does not provide clear guidance on how to meet the user needs in the design of particular user interfaces, so the iterative formative evaluation of design prototypes seems the only reliable way to reach design excellence. It can also be noted that the empirical research on this theme is still very fragmentary.

Table 2. Cognitive needs of museum visitors

Cognitive need	Explanation
Curiosity about the invisible parts of specimens	Museum specimens are usually unavailable for taking them in visitors' arms and often have parts invisible from the observer's position. Providing visitors with different hidden views of objects and their magnified images on a kiosk screen can satisfy visitors' curiosity.
Multisensory perception of specimens	Although authors do not provide an explanation of this need, it can be supposed that kiosks may be used, e. g. for audio-visual reconstruction of the artefacts' context of use.
Comparison with old and modern lifestyle (mostly applicable to history museums)	Visitors often do not understand the purpose of artifacts of past civilizations, how they were used and what role they played in the life of our fathers of old. Kiosk presentations can answer these questions.
Visualization of oneself using the specimens	Visitors often make gestures obviously indicating that they imagine themselves holding or wearing the objects displayed in a museum. These desires always remain unfulfilled due to the restricted museum environment but can be satisfied with the use of kiosk technology.
"One-click-one-toffee" approach to information presentation	Visitors generally have a narrow attention span and have no patience to consume detailed information accompanying museum exhibits. Because of this authors recommend that information in the kiosks applications should be presented in small stimulating and memorable pieces that can be absorbed in one glance. In their opinion, this could also prevent crowding over the kiosk.
Stories associated with the specimens	Visitors are not very interested in historical dates and scientific descriptions of artefacts, but they love stories, drama and performances associated with museum specimens. Multimedia kiosk presentations can be dynamic and intriguing enough to meet this craving for theatre.
Shared cognition within groups	A large number of museum visitors come in groups and this invokes significant social interaction in response to the museum specimens. Kiosk interfaces should encourage and support collaborative activities of group members including discussion, sharing opinions and knowledge acquisition.
Inarticulate cognitive map of museum's architecture	Many visitors are unable to develop an adequate cognitive map of the architectural layout of galleries in museums. Interactive plan of the museum premises can greatly help visitors in their orientation within the museum halls and facilities. This can also unload museum workers from their permanent task of helping visitors to find their way in the museum.
Holistic experience of museum artefacts	Museum visitors often cannot develop comprehensive understanding of museum specimens and the experience of them because the artefacts are disconnected from their original environment and the context they belonged to. Kiosk technology offers a potential to provide a more holistic view of museum artefacts by simulating their natural contexts.

Musculoskeletal complaints on kiosks' usage

Generally, two different ergonomic drawbacks associated with touchscreens were reported: a well-known "gorilla arm" effect (a feeling of heaviness in the upper limbs) for vertically mounted displays and the neck fatigue for horizontally mounted touchscreens [115][134]. However, these discomforts were reported for considerably long periods of continuous work with touchscreens. They may not be the case in typical contexts of kiosk use in museums. In particular, Shin and Zhu [134] did not find any significant cumulative discomfort or physiological effects for periods of upto 15-minute *intense* use of a 23-inch touchscreen (however, Kang and Shin [73] study revealed statistically significant increments in subjective body discomfort ratings *after* 20 minutes of web browsing on the same touchscreen, but it is

known that museum visitors typically spend less than 20 minutes in exhibitions, regardless of the topic or size [131]). In a museum situation where a user is in control of his intensity of work, can alternate hands and can freely stop his interaction with a kiosk at any point it is difficult to expect that kiosk use will lead to serious musculoskeletal discomfort complaints.

Then, a possible body discomfort of touchscreen users could be lowered by user interface design improvements. For example, Kang and Shin [73] recommend placing menu items in the lower area of a touch display. A similar recommendation can be proposed in case of *large* displays: in order to reduce the amount of hand movements when using an interface which require, for example, scrolling of an image or a map, scrolling controls can be combined into a compact group (Figure 2).
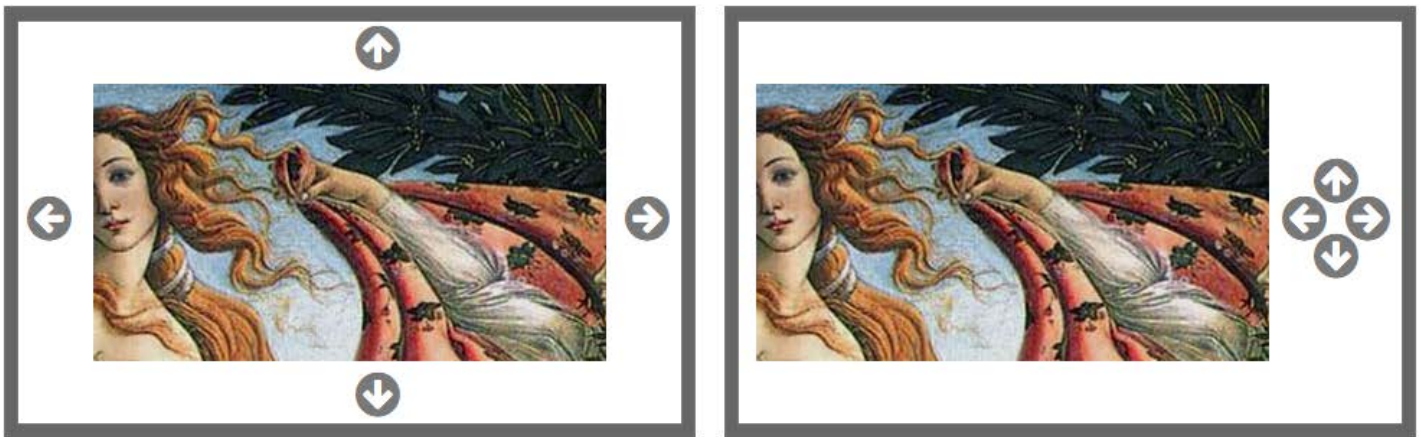

Figure 2. Example of grouping the controls to reduce hand movements

Usability of kiosks in museums

Standard steps of a multimedia exhibit development for museum interactives include [37]: (a) making decisions on the content of the system; (b) collection of the material; (c) visual design and software development; (d) formative evaluation of product usability; (e) integration of the product in a museum exhibition; (f) summative evaluation of the product effectiveness; (g) study of the long-term effects of the system on visitors; and (h) study of the impact on museum workers.

It would be wise to design kiosk interfaces according to evaluation criteria a system may undergo in the future. A framework for evaluating and comparing interactive installations in museums has been proposed by Gonçalves, Campos and Sousa [56]. Their M-Dimensions framework (M stands for Museums) includes 10 dimensions for guiding the design and evaluation of interactives, tailored specifically to museums. The concept of the framework was based on (1) existing usability evaluation methods, (2) literature on museology, (3) iterative communication with experts in interaction design for museum interactive installations, and (4) a long-term study of interactivity in a number of different museums. Although the M-Dimensions framework is intended for evaluation and comparison of the quality of the interactives in museums, it can also be used during design stage to avoid many interaction design mistakes that can be overlooked until usability testing *in loco* is performed with real museum visitors. M-Dimensions framework is described in Table 3.

Although their set of scales looks plausible, unfortunately, authors do not provide sufficient psychometric analysis in support of the validity and reliability of the proposed scales. Then, descriptions of some dimensions look somewhat overlapping while other dimensions look as a mix of rather different factors (for example, "Visibility" dimension involves aspects related to both physical location of interactives and their user interface features like identification of buttons

and readability of texts). Anyway, this is still the most comprehensive set of evaluation criteria available in the scientific literature to date.

Table 3. M-Dimensions framework

Dimension	Description
Interaction style adequacy	How adequate is the interaction style of an interactive installation with regard to its goal. Ease of use: the installation may be more or less difficult to use, and the visitor feels more or less tired when using it. If the style of interaction is related with the information content and the museum atmosphere, improving or not the engagement of the visitor with the module.
Area integration	The installation's degree of isolation regarding the subject matter and whether the narrative of the exhibition is maintained or fragmented. The installation should perfectly fit the narrative and the spatial context, should be physically close to other related elements that complement and contextualize the interactive installation. The focus of the visitor will be the work of art/content and not the technology.
Visibility	Ability to show users what they need to complete a task without distracting them. The module must be in a visible place where all visitors can see it. Moreover, its disposition must encourage its usage and it must be identified with a title or labels to facilitate the interaction. Installations should provide immediate interaction capabilities and the visitor shouldn't show a hesitation, because all the elements needed are visible and available, without the presence of distracting objects, both physical (e. g. reflections on the screen because of high luminosity) and digital (e. g. difficulties in recognizing control buttons or difficulties in reading because of improper fonts). Physical location of the installation within the visitor's passway through a museum space.
Feedback	The system should always keep users informed about what is going on, through appropriate response within reasonable time. A museum installation must effectively inform the visitor of events, results, progress, state changes and the remaining information that the visitor needs to complete the desired task while interacting with installation. The user interface must show useful information recognizable and understandable through visitor language.
Structure	Organization that reflects the intrinsic or familiar organization of things: things that are similar or related are supposed to resemble each other. Element organization or arrangement inside the installation or between similar installations. Layout, format, visual associations and distinction of the installation's elements. Consistency within the module or between similar modules.
Reuse	Recycling visual elements and interaction patterns so that interfaces are not only consistent, but also contain fewer distinct things to understand and master. Reuse of elements and behaviors inside the installation or between similar installations.
Simplicity	Genuine elegance and parsimony rather than "simple-minded reductionism". Simplicity can be affected by many factors, such as lack of identification of the installation, lack of tips for using, unexpected behaviors, malfunctions and so on. The interaction with the module should be immediate and successful during the time of use by the most of the visitors (90% to 100%).
Learning	Giving visitors a choice depending on their attention span on what to display to them. Promoting critical thinking in visitors and have them reach their own conclusions on things. Free choice, addressing multiple points of view, enhancing visitor's curiosity.
Entertainment	Participatory experiences that promote fun and allow the visitor to see new and interesting things in a relaxing and aesthetically pleasing setting. Installations should be pleasant to use and interact with, increasing the level of engagement and time of use. Time spent on interaction as a measure of the level of engagement.
Collaboration	Being able to be used/viewed/enjoyed by multiple visitors simultaneously. An installation is considered collaboratively good if it can be directly used by up to 4 visitors at the same time and others visitors can easily see the interaction and discuss its results among them.

A different, more psychometrically substantiated scale for measuring user experience with museum audio and multimedia guides has been developed by Othman, Petrie and Power [109][110][111]. Their three-factor Multimedia Guide Scale (MMGS) is described in Table 4.

Table 4. Multimedia Guide Scale factors

Factor	Description
General usability	Whether the functionality of the guide is appropriate, whether it is easy to use.
Learnability and control	Whether the guide is easy to learn to use, whether the user felt in control, and whether the information presented in a meaningful ways.
Quality of interaction	Interaction with and feedback from the guide. Ability of the guide to respond to the user's actions.

Although these scales were the result of principal components analysis and therefore should be considered as independent measures, authors' *interpretation* of resulting scales looks not too convincing, in particular, their descriptions of scales "General usability" and "Quality of interaction" do not provide clear understanding of differences between these two scales. Another shortcoming of MMGS is an obviously small number of evaluation factors and a lack of practically applicable design guidelines.

Museum interactives tend to appeal particularly to children [18][19][80]. There exist usability heuristics for evaluation and design of e-learning applications for children [7][8]. In addition to Jakob Nielsen's ten basic usability heuristics, these heuristics also include a number of heuristics specific to children and learning: Multimedia Representations, Design Attractive Screen Layout, Use Appropriate Hardware Devices, Challenge the Child, Evoke Child Mental Imagery, Support Child Curiosity, Learning Content Design, Assessment, Motivation to Learn, Interactivity, Accessibility.

Supporting group interaction has been shown as the insistent need by a number of studies which showed that the group museum experience is a critical aspect of their satisfaction with the visit [59][64][70]. Results of Campos ea study [19] showed that the most enjoyable installations are those which allow for and encourage collaborative activities. Computer-based interactives with a traditional display do not allow for a group interaction because it is difficult for observers to understand where the active user is looking at and what exactly he is doing at the moment. In contrast to PCs, touchscreens provide much better visualization of interactions and therefore help groups to observe each other and to engage collectively [65][70].

Traditional HCI design principles like the affordances are very important to museum interactives: if the visitor cannot understand the installation's purpose and usage in the initial seconds, they will abandon further attempts to interact with the device [19]. Responsiveness, or reaction time of an interactive application is found to be another crucially important factor for museum visitors [80]. Visitors expect computer exhibits to respond instantly [49] and if a computer interactive is slow to respond (system response to user input takes more than 2 s), this causes users' frustration and they may be quick to assume that they did something wrong or they may start to feel that a system fault has occurred. To prevent user's abandonment of further interaction with the application, a clear indication should be provided that the system response is in progress [93].

User interface should be also adaptable to the amount of time a visitor plans for his visit to the museum [52].

Interactives should be integrated into other exhibits so that they augment but do not depreciate the visitor's experience [98].

Gammon & Burch [49] present a consistent pattern of visitor needs derived from user testing of over three hundred kiosk prototypes at the Science Museum (London):

- the pacing of content, instructions, and activities needs to be much faster than would be found on a conventional computer game or website;
- visitors very rarely use help buttons;
- educational content in interactive games must be incorporated throughout the activity and not relegated to the concluding screens;
- the main navigation buttons used by visitors are the forward, back, and home page buttons;
- touchscreen interfaces work well, provided that visitors can clearly identify which parts of the screen are active;
- it is important to provide both visual and auditory feedback when an on-screen button has been pressed;
- visitors expect computer exhibits to respond instantly;
- kiosks are typically used by two or three visitors at a time.

Science Museum (London) also provides a set of guidelines on the design of touchscreen interactives and recommendations about testing and evaluation of interactive prototypes [129][130].

General information about basic kiosk usability and ergonomics can be found in [22][26][84][94][125].

Despite the long history of kiosk use in museums, design of user interfaces for museum interactives is still a kind of "black art" [74] and we do not have an elaborated set of concrete guidelines on the design of usable user interfaces for museum kiosks or user interface design patterns for museum kiosks comparable to those developed for other devices or industries like mobiles or e-commerce. This fact may mean that a kiosk supplier for museums should enroll specialists experienced in museum kiosk usability engineering into their development team.

Accessibility of kiosks in museums

Kiosks in museums should be approachable and reachable by all of museum visitors who want a meaningful and relevant experience over which they feel in control [54]. To work optimally in museums, accessibility principles should be integrated into all aspects of the museum visitor's experience including the digital media. Knowledge of the needs of people with disabilities is key to quality service provision. Digital media need to be part of a holistic approach to accessibility and they should be allowed to reach their full potential [149]. 56% of museums and other cultural institutions surveyed in [36] indicated that one of main objectives of their meetings with hi-tech companies was to improve accessibility of their institutions.

Touchscreen kiosks have potential accessibility issues shown in the Table 5.

In many countries it is now the legal responsibility of museums to address the issues facing disabled people when they access museum collections and provide adequate services for people with disabilities [33]. Different countries have their local regulations relevant to the design of kiosks. For example, the US Department of Justice issued Americans with Disabilities Act (ADA) standards [32] which apply to places of public accommodation, facilities in the private sector, and to state and local government facilities, require all public places to be accessible to people who use wheelchairs, the blind, and the deaf. The guidelines include a variety of regulations applicable to both physical construction and user interfaces of public terminals [34][47]. Although ADA guidelines provide a lot of images, quantitative dimensions and characteristics, however, the main problem encountered by kiosk suppliers is that ADA requirements are not clear in many cases and that these requirements can overlap in the process of kiosk design. Another problem is that it is practically impossible to design a kiosk that fully complies to ADA requirements and is cost-effective at the same time.

Table 5. Potential accessibility issues for touchscreen kiosks

Potential issue	Requirements
Physical access	Disabled users (in particular, users in wheelchairs) must be able position themselves so they can interact with a kiosk. This includes a clear path to a kiosk and sufficient clear space in front of it.
Reach and visibility	Components of a kiosk must be easy to reach, clearly seen from a seated position and be easy to interact with.
Display interfaces	Issues include glare, viewing angles, parallax, text and icon size, complexity or inconsistency of user interface and system timeouts.
Touchscreen interfaces	Touchable screen areas must be reachable by users seated in wheelchairs. Blind users and some users with low vision should be offered an alternate user interfaces such as secondary hardware controls or a voice interface.
Feedback	A kiosk should provide a feedback in a variety of sensory modalities comprehensible to a user. Disabled users impacted by this requirement include deaf users and those who are hard of hearing, blind users and those with low vision, and users with upper mobility impairments.

A less restrictive and thus more workable set of accessibility guidelines for public access terminals has been proposed by the Irish National Disability Authority [107]. Their guidelines are grouped in two "priorities": Priority 1 ensures that the public terminal can be used by most people with impaired vision, hearing, mobility, cognition, and language understanding, while Priority 2 includes requirements for people with cognitive impairments or multiple disabilities. Each guideline provides information on the guideline rationale, directions and techniques on the guideline implementation, and instructions for checking the compliance to a guideline. A review of these and a number of other general-purpose accessibility guidelines and standards for public access terminals can be found in [82].

Smithsonian Institute, a leader in promoting accessibility in museum exhibits, has developed a comprehensive volume of guidelines specifically tailored to museums [137]. Their guidelines' special section on audiovisuals and interactives provide recommendations on instruction presentation, control and operation, heights and locations, glare and reflection, and basic user interface characteristics of interactive elements for museum interactives including touchscreens.

It may be useful to evaluate kiosks with regard to both physical and intellectual accessibility with small focus groups of people with different types of disabilities [38]: (1) mobility difficulties; (2) visual impairments; (3) hearing difficulties; (4) learning difficulties. These focus groups should include both people with disabilities and their companions or carers as well, and both museum visitors and non-visitors. The areas to be examined include [38]: (a) physical accessibility of the display; (b) intellectual accessibility of the story display (e. g. quality and length of text and audio, understanding of messages); (c) attractiveness of design (e. g. appropriate use of colors and images).

People over age 65 typically experience decreased visual acuity even when they consider themselves "normal" as opposed to disabled. These visitors often complain that they cannot read the labels because of small print, low contrast, low light, and inconveniently low placement. These impediments affect all visitors but have special importance for aging visitors [54]. Blind people commonly state that they don't visit museums because there is nothing for them to enjoy. Today there are virtually no visually impaired walk-in visitors in museums [54]. Illiterate or semi-literate people prefer icon-based interfaces to speech-based interfaces or traditional text-centered interfaces [82]. User interfaces for people with motor control disabilities require larger touch-activated screen objects. While the performance of non-disabled users reaches a plateau at button size of 20 mm, performance of disabled users improve as button size increases to upto 30 mm [23][24][131].

An interesting case of parallel wheelchair orientation (Figure 3) for people with upper extremity motor control disabilities has been investigated by Chourasia ea [24] (they analyzed this case because ADA laws allow for facilities to

provide either the front or parallel orientation). They found that this position requiring twisting of the torso caused a decrement in touchscreen performance. However, it has been shown that the adverse effect of parallel sitting orientation on touchscreen performance could be ameliorated by using larger button sizes (≥20×20 mm).
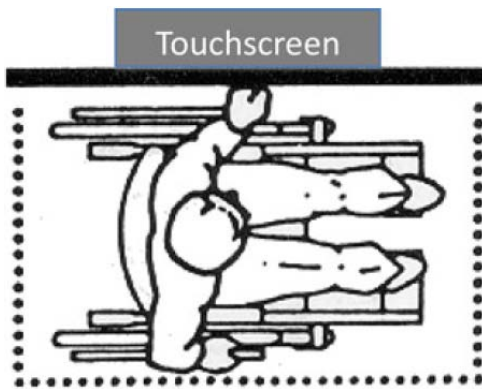

Figure 3. Parallel orientation to touchscreen of an individual in a wheelchair approaching a kiosk (from [24])

One of the technical approaches to serve elderly visitors and people with disabilities may be use of magnetic stripe cards or smart cards that can store personal information about the type of disability and other user's information like his language preference. When applied to a kiosk, the card switches its interface according to user characteristics, for example, makes a switch to a low-vision look and feel of the user interface or automatically adds subtitles to a video containing voice narration [82].

A comprehensive study of issues and potential solutions related to kiosk accessibility has been prepared by Fain [42].

It should be always taken into account that accessibility does not guarantee usability and there is a permanent need to balance between accessibility and usability in the user interface design [82]. At the same time, an interesting finding among different museums is that experiences and materials developed for disabled visitors were reported by museum curators as being of benefit to *all* their visitors – a conceptual leap beyond the typical attitude that design for accessibility ignores visitors who are not disabled [145]. This research did not involve any study of perceptions of non-disabled people, however.

Optimum/unsuitable physical environments for kiosks' usage in museums

A well-known lighting problem with kiosks is *glare* from the sunlight or artificial light sources [94]. Typical tactics users attempt to avoid glare are changing their viewing angle and shielding the display with their body or the heel of the hand. However, this is often not suitable for children or individuals in wheelchairs because they may be looking at a display from the bottom upwards [42][44].

To avoid glare from the touchscreen the following measures can be applied [42][94]:

- careful location of a kiosk (for example, positioning a kiosk in areas where glare is less likely, such as a place that does not receive direct sunlight);
- use of anti-glare display technologies;
- providing an adjustable angle displays;
- using a hood over the display to shield it from direct light (a possible problem here is that a poorly designed hood may block visibility for tall users);
- reducing overhead lighting near a kiosk or directing it away from the display.

Intensity of ambient lighting in museum rooms is important for kiosk use too, in particular, because high illumination intensity can cause screen images to fade and there exists a non-linear dependence between illumination intensity and visual performance of users working with LCD screens [90]. Although concrete recommendations on reaching the optimal balance between ambient light intensity and display's own luminance levels are yet to be developed, it can be already said that these parameters should correspond to each other. For example, museums often contain both highly illuminated facilities and specially darkened rooms (e. g. for jewelry exhibitions) and this may mean that a kiosk interface management system should accommodate to these changes in ambient lighting intensity by using brighter and higher contrast text and imagery on displays placed in well-lit environments and less bright themes on displays in darkened rooms. (However, in the latter case attention should be paid to the fact that dark colors highlight finger prints and increase glare [20].)

Background noise in museums may also be a problem for kiosk use. Research on visual performance shows that noise intensity lower than 30 dBA may be the optimal condition for visual information processing tasks on LCD screens and that performance reduces significantly at 60 dBA and higher noise levels [90]. However, even the suggested *ideal* background noise level in modern museums equipped with heating, ventilation and air conditioning (HVAC) systems is ≤45 dBA [21], while actually measured background noise levels might well reach 66 dBA in a museum room facing an urban street [21] and 75 dBA in a museum which was regularly approached by the aircraft [88]. These circumstances may require appropriate measures to improve quality of kiosks' auditory output [42]:

- providing incremental volume control with output amplification up to a level of at least 65 dB;
- providing a volume gain of at least 20 dB above the ambient level for environments where the ambient noise level is above 45 dB (also, the volume should be automatically reseted to the default level after every use);
- providing a headphone jack which allows visitors to attach headphones;
- providing redundant visual output in the form of graphics and text for important audio output.

Temperature and relative humidity (RH) requirements for museums are dictated by optimization of two factors: (a) conditions necessary for preservation of the artifacts specific to concrete collection type (paintings, sculpture, furniture, textiles, metalware etc.), and (b) physical comfort of museum visitors and museum staff working in the galleries. These environmental conditions are subject to temporal fluctuations, for example, an inflow of visitors produces an increase in temperature and humidity [103]. Environmental requirements for permanent and loaned museum collections are usually different, but in general, recommended levels for temperature in museums lay in the range of 18-24 °C while for RH levels the recommended range is 40-70% [11][103][105][113]. Review of technical characteristics of *indoor* kiosks offered by the industry shows that they usually can operate at much more wider temperature and humidity ranges (typically, within 10-40 °C and 20-80% RH ranges). This means that museum environments must be quite comfortable for the typical operational conditions of kiosks intended for indoor use. However, before installation of new kiosks in the galleries, the museum curators should be warned that large-screen kiosk devices can produce considerable heat so they may have to adjust their HVAC systems correspondingly.

Museums' management on application of kiosks

The museum ideal is visitor engagement [17]. For years, museums have been the space of their curators, who were solely responsible for the museums exhibitions [17]. However, currently museums turn to technology in order to better satisfy visitor expectations due to technologies' ability to deliver new interactive experiences [142].

Museums must place the visitor at the centre of the museum, its services and resources and this requires that all museum staff, not only those who have direct contact with visitors, but also the staff responsible for development of

museum interactive experiences, understand that each should contribute in creating the best environment for visitors to access and enjoy the collections and the museum environment and this contribution should be based on the understanding and responding to visitors' needs [151].

Designers must understand the social, cultural, economic and personal exchanges and experiences that take place within the museum setting [90]. Designing interactives in museums is not solely about enabling access to the collection or organizing information about museum specimens; nor is it focused only on the incorporation of technology into exhibits for the sake of novelty. Museums must facilitate users' ability to make meaningful connections to museum collections both individually and socially within the museum environment [54].

Interactives should be an continuation of the museum's mission; otherwise, they have the risk of becoming insignificant add-ons. Developing rich and meaningful interactives is a difficult task. A lack of institutional commitment and of clear understanding of the goals and expected results may doom the efforts to failure [3].

It is not sufficient that new technologies enhance the visitor experience; it needs to be demonstrated that these new technologies enhance the visitor experience better than competing technologies and in ways that are cost-effective [11]. Planning a museum exhibition must balance functional requirements, aesthetics and total cost in museum exhibition design by employing inter-disciplinary such as project management, subject specification, cost-benefit, design aspects, and production [90]. Conducting inter-disciplinary museum exhibition projects is more complex than many other design projects. Managing museum exhibition design projects involves monitoring, planning, design, and technical problems in coordinating all the specialist disciplines involved in decision making. Because of the diverse features of a museum exhibition, managing the project requires the active participation of different professions as well as a specific curatorial approach [90].

The 2013 Dosdoce.com survey [36] revealed the fact that in most cultural institutions it is often difficult to identify the specific staff responsible for defining, coordinating and supervising the digital strategy: in most cases there wasn't even a department or a person responsible for the definition of the institutions' digital strategy and these tasks are usually distributed among several departments such as public relations, marketing, web maintenance etc. In addition, 71% of the surveyed institutions claimed that they did not have enough qualified personnel to incorporate more technology to their centres.

Museum professionals and designers of interactives often work in a rather hermetically sealed environment, developing interactive experiences that do not take into account the visitor's needs and preferences [3]. If museums want to meet the needs of their users, someone in the museum must work as the users' advocate, approaching problems from a user-centered perspective. When user needs are not being met, the museum information professional will likely be the museum staff member most attuned to the user's needs and best suited to argue the user's case. They are likely best positioned to serve as user-centered mediators between the museum and its users, advocating information needs for multiple users, and arguing for such issues as usability and accessibility [97].

Museum curators are interested in putting exhibit content production, management and visualization activities into the museum staff hands [141]. Properly designed kiosk-based systems offer museum staff the flexibility to easily update the exhibits' information, accommodating more frequent and easy changes of the permanent displays [40].

Content management systems (CMS) are attractive to museum curators because a CMS enables flexible organization and management of digital information so that it can be readily configured in different ways for different purposes and audiences. The same information that appears in a museum catalog could be used in an artist's profile or an education resource. The purpose of content management is to deliver rich digital content across diverse platforms – online, onsite,

wirelessly, in print – to where audiences can use it. Information available on a museum kiosk can be published simultaneously to the web or laid out for print publication [117]. Therefore, a kiosk software supplier should also provide their own CMS or their software should be readily integrated with a CMS a museum already uses.

At the same time, a CMS must allow to display different information on different kiosks according to each kiosk's vicinity [92].

Museum staff needs a way to remotely manage the data from one place [92].

The functionality provided by a CMS solution may include the following: configurable screens, monitoring of kiosk health, usage statistics, the ability to remotely deliver content to the kiosks, and application lockdown to secure the museum's data and network [92]. Usage statistics is important for museum curators because it provides them with useful information about the users' interaction with the system: how many users accessed the application and at which locations, which and how many pages they were viewing etc. Based on this data, system admins can fine-tune the user interaction to improve the visitor experience or evaluate the effectiveness of the system's current configuration [52].

In a cross-disciplinary museum projects the main challenge may be related to communication issues between interaction design team and the artistic direction of the museum because there is the language barrier between these professional groups [19]:

> This comment expressed by one of the designers/programmers was common to many others: "Change was constant – and communication was a true challenge, since it was difficult for them to communicate us the whole point of. And when we moved from the laptop to an actual kiosk or projection, we noticed how different their opinion was regarding every aspect of the design and development" (Developer/Designer). Another interesting observation was: "They [the artists] were completely focused on the MS PowerPoint model – they thought kiosks and interactive installations had to be designed and programmed as if they were PowerPoint presentations" (Developer/Interaction Designer).

McDermott ea interview-based study [101] of museum curators and designers analyzed their attitudes, motivations, expectations and aspirations when creating interactives, and also resources and working practices when creating and implementing them. The results show that despite a general predominant interest amongst all the museum curators in the incorporation of digital interactives into museum exhibitions, there is an insufficient understanding of what is achievable with interactive exhibits. In addition, the study revealed a number of advantages and disadvantages with regard to the use of digital interactives ranging from positive expectations (e. g. building of museum image as an up-to-date institution in order to attract audiences, and being able to present intangible or dynamic content) to negative expectations (e. g. the fear of been upstaged by technical exhibits which may result in the distraction of visitors' attention from museum specimens). Research also revealed insufficient attention to using low cost prototypes and formative evaluation of interactives, activities that are strongly recommended by usability professionals to ensure successful incorporation of interactives into museum exhibitions.

Lin [90] presents the MEDP (Museum Exhibition Design Process) model for managing the design process in museums, a systematic framework which can be described as a plan of design activity, particularly for science museum exhibitions. The model proposes a prescriptive design process framework applicable to all design participants to ensure their systematic and effective work, and includes the aspects of the design process that need to be modelled for museum exhibition design, criteria for the design work that could improve the design process, design roles that could effectively achieve project aims. The framework describes such activities like management of design documentation, design brief, sketching plans and drawings, development of checklists to ensure that none of design issues has been overlooked, production specification and production plan. However, this framework is primarily concerned with mapping

information flows and does not show how a process is performed, but what is needed to perform the tasks and what design work should be produced.

Based on MEDP framework, Gillette, O'Brien & Bullard [54] present a case study of the design process for a kiosk system in an anthropology museum. This research included analysis of design documentation and interviews with museum curators, administrators, designers, archivists and librarians. The researchers examined the results in the context of collaboration in the design process, and sought to expand the notion of design as outcome (i. e., a system) to show the multi-faceted and complex process of design in a museum setting. Their research is useful to understand the rich and complex nature of the human component of design work and characteristics of individuals involved in developing kiosks. Authors suggest that design process should be seen as a dialogue between organizations and users, between the members of a design team, and between users and designers.

Marty [96] states that a museum information professional must serve as user advocate approaching problems from a user-centered perspective to ensure that information technologies are truly meeting the needs of the museum's visitors. To help museums to transform a museum to a more service-oriented information organization and keep up with changing needs of museum users, the museum information professionals need to work closely with a broad spectrum of the museum's users, examining their information needs from multiple perspectives, and advocating those needs to the appropriate museum decision-makers. This task becomes increasingly important as museums become more focused on meeting the information needs of their users, and museum users demand more accountability from museum personnel. Modern museum information professionals "serve as user-centered mediators between the museum and its users, advocating information needs for multiple users, and arguing for such issues as usability, open access, standardized data, and the availability of appropriate information resources to all users. They ensure, as much as humanly possible, that each user has a successful interaction with the museum's information resources".

The level of familiarity that people use and experience multimedia technologies in museums

Kiosk are one of the earliest digital technologies that became a frequent practice in museums so it can be expected that contemporary museum visitors are well acquainted with them.

Museum visitors love interactives, but they are *not always* the most popular elements of the exhibition [44]. Most today's museum visitors confess that the addition of multimedia into museums allows for different degrees of information depth and supports individual flexibility and choice, but multimedia is rarely the main cause why people visit museums. Anyway, multimedia will continue to be the critical component of museum exhibitions, especially for Millennials who are comfortable and extremely perceptive to technology. Multimedia exhibitions are a strategy for creating museum comfort today for museum visitors of tomorrow [44].

Although for some museum visitors interactive technologies might be unfamiliar and deterrent, for others, exactly the same interfaces may seem already obsolete. For example, young visitors accustomed to touchscreen mobile devices often expect museum interactives to respond like smartphones or tablets, and often find museum interactives to be lacking in responsiveness and usability [80].

Gammon [48] describes lessons learned from deployment of screen-based computer interactives and observations of visitors' use of these interactives in the Science Museum (London).

Digital competitors of kiosks in museums are tabletops and handhelds (museum-owned or visitor-owned). Browsing research publications appeared in the last 5-7 years yields an impression that proportion of publications on kiosks, tabletops and handhelds is approximately 1:5:20 correspondingly. It is difficult to expect that tabletops will gain widespread use in museums in the long run (simply because they are too expensive and occupy too much valuable space), but handhelds obviously are the current focus of research because they are the confluence between at least five "hot" research themes: mobile computing, ubiquitous computing, social computing, adaptive/personalized computing and augmented reality computing. Researchers and technology leaders currently perceive kiosks as a technology of 90s and it is obvious that in the foreseeable future efforts and financing will be directed to handhelds.

Vom Lehn & Heath [86] compared the use of kiosks and handhelds (PDAs) in two different art museums during a video-based ethnographic study and delineated their advantages and disadvantages (Table 6).

Table 6. Advantages and disadvantages of kiosks and PDAs

	Pros	Cons
Kiosk	Offers dynamic content Adds multimedia to texts Provides interactivity	Leads to queue Can transform visitors into passive participants (removes the need to look at the real artifacts) Makes it difficult to look at both artifacts and screen
PDA	Provides a mobile experience to visitors Contextualizes information for visitors Offers more flexibility	Isolates visitors from their companions or group Makes the coordination between real artifacts and objects displayed difficult

Although conducted in the PDA era, conclusions about the disadvantages of handhelds may still be relevant to the modern smartphones despite their obvious technological excellence and much more rich capabilities. A comparative research on kiosks and contemporary smartphones is yet to be conducted.

Gammon & Burch [49] describe some additional advantages handhelds offer to museum visitors: opportunities to capture and take back to home reminders of their museum experience and to extend it far beyond the confines of the actual visit; personalized interpretation since each visitor has his own portable computer terminal, accessing the information or activities they want, when they need them; moving the device to the position best suited to simultaneously view the object and its accompanying interpretation; opportunity to build communities through wireless networking, allowing visitors to communicate at a distance with others in or out of the museum, to share ideas and experiences. Traditional kiosk technology obviously lacks these advantages.

This does not mean that kiosks in museums have no future. First of all, they have an advantage handhelds will never beat: large screen (with all that it implies). Then, museum curators' opinions about technologies suitable for their institutions may well be different from those of researchers and technocrats. Handhelds are a hotspot, but kiosks are familiar and popular technology that already outlasted first generation of handhelds in museums, PDAs. Active experimentation with PDAs in museums began in 1998 and resulted in at least two books ([143][139], published in 2008 and 2011) and a myriad of scientific articles. These massive research efforts did not lead to any visible proliferation of PDAs in museums, however, and when Marty [98] notes that "the history of interactive devices in museums can be read as a history of failure", he means mostly PDAs. He continues: "As more museum professionals consider incorporating interactive technologies in their galleries (especially portable, personal devices), it is important to study how, when, for whom, and under what conditions these devices improve the museum visit". At present we see that a new wave of research on handhelds, now smartphones, has been evoked by "iPhone revolution" and there are no signs of any attenuation.

This may mean that under present circumstances offering kiosks to museums as a standalone technology may be not the best strategy. There are reasons to think about (1) integration of kiosks with handheld technologies and also (2) enhancing the device functionality beyond pure touch screen by adding such technologies as NFC, motion detection, gesture recognition, face recognition etc.

The public's view on kiosk use in museums

Research shows that museum interactives enhance visitors' experience by offering them more engaging interactions with the museum environment and attracting visitors with the technology's novelty [37].

In two researches [27][104] of adult visitors to British Galleries (museum displaying applied art and design from 16th to 19th centuries) conducted in 2002-2003, 87% of respondents felt that kiosks were appropriate and beneficial for the museum although only 26% actually used them which means that the majority of visitors were positively disposed towards the use of kiosks even if they did not use any themselves. 83% of those who used at least one interactive exhibit reported that interactives encouraged them to look more closely at the museum specimens. Those 6% of visitors who expressed negative views about the interactives either did not need them (academic or professional visitors), could not use them (e. g. because of time constraints) or were worried that other people might not like them. It was also found that kiosks were mostly used by family groups than by adults and children.

In Brady's study [18] 62% of respondents said they had actually used the kiosks and common explanation for not using them was that visitors were constrained by time.

Adams & Moussouri [3] present comparative results of perception of interactive and non-interactive museums by family visitors. Non-interactive museums were described in terms like "boring", "nothing to do", "passive", "labels", "cannot absorb anything", "get in, get out" etc. In contrast, interactive museums were characterized much more positively as "exciting", "enjoyable", "colorful", "get involved, participate", "use all senses", more educational", "relaxing", "stay longer", "remember (long-term effect)" etc. Authors also noticed that interactives promote visitors' more deep interest to the non-interactive exhibits of the museum engaging them in object-centered inquiry.

Consumers in today's society have a multitude of entertainment options to choose from, so museum visitors expect much more activity than just passively viewing artifacts, they want to touch, interact and socialize, they want an experience that enriches their lives intellectually, spiritually, and physically [11][44]. Museums have to adopt visitor-centered strategy to remain attractive leisure time venues.

One of the basic facts revealed by museum audience research is that use of multimedia is highly self-selected: in any exhibition not all visitors interact with all of the media elements. However, media is an important option for *some* visitors and there exists a significant percent of visitors who spend a considerable time, if not most of their time interacting with multimedia [44].

People spend time working with multimedia interactives only if they are interested in the topic and want to learn more. Otherwise, they will not pay attention to a digital interactive no matter how flashy, expensive or elaborate is the media technology [44].

A crucially important factor in the success of museum interactives is visitors' participatory experience with them [135]. The term 'participatory' means involving visitors in a conversation with the museum and with other visitors [3]. Contemporary users are well accustomed with user generated content and social media features offered by Web 2.0 technologies and they often expect a similar functionality from the museum kiosk applications. For example, visitors

would be happy to look at other visitors' *ratings* of particular museum specimens to compile a list of museum "must-sees" and to plan their (often time-restricted) visit to the museum exhibits more efficiently. A possibility to leave *comments* (another widespread and highly used functionality of Web 2.0) about the museum exhibits can become a natural replacement for traditional museum guestbooks (of course, the museum CMS platform should have the possibility to remove a low-quality or offensive visitor-generated content). Another possibility is when visitors can use kiosks to produce e-cards or media pieces (photos or short videos) to *share* them to their friends and family via email or MMS. Visitors' participatory experiences may stimulate not only their engagement with museum collections during their on-site visit to the museum but also promote re-engagement with the museum within a post-visit stage of visitors' journey via the museum's website [135].

Some researchers discuss the theme of "technology fatigue" phenomenon in museums. Technology fatigue was reported as early as in late 90s [48][49] as an effect when visitors get so familiar with using digital technologies in their everyday life that the prospect of interacting with them in the museum gallery ceases to be novel, interesting or appealing [147]. A person who already spent a day looking at a computer display at his workplace may not want to use a computer in a museum. Tsoroni [147] suggests two strategies for combating technology fatigue: to limit the digital interactive offer in the galleries and to invest in the creative use of more cutting edge technologies. The author admits however that the techno-fatigue phenomenon has been observed anecdotally by museum professionals and it got very little theoretical consideration so research is needed into the causes and symptoms of technology fatigue and the strategies for combating it.

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