Designing Technological Support for Meaning Making in Museum Learning: an Activity-Theoretical Framework

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Abstract
The paper proposes a conceptual framework, informed by activity theory, for designing technological support for meaning making in museum learning. The model describes a complex interaction between two activity contexts, the one associated with learners’ own interests, goals and expectations, and the one associated with the design, functionality, and history of a museum artifact. The model is intended to be used as an analytical tool supporting a systematic exploration of specific interaction design solutions for enhancing learners’ experience in museum settings.

1. Introduction
It is widely acknowledged that information and communication technologies (ICT) can help realize the full potential of museums as places for learning (e.g., [8]). However, concrete strategies and solutions for employing ICT in museum learning remain to be determined.

With some exceptions, designing ICT solutions for museums is currently a variety of “black art”. The skill and creativity of people who design technology-enabled museum exhibits, settings, and special events may produce extraordinary results. Far too often, however, the results are discouraging. Many ICT implemented in museums fail to meet the real needs of their users and are plagued with usability problems [22]. Modern technology may not fit well with museum settings and undermine the perceived authenticity of a setting [10]. Mobile guides tend to distract visitors from museum artifacts and cause “….what is known as the “heads down“ phenomenon, when visitors are focused on displays of their mobile devices rather than museum exhibits” [17].

One lesson to be learnt from current attempts to implement ICT in museums is that relying on designers’ intuition alone can be risky. There is a need for analytical tools fostering a more systematic and reflective approach to design, implementation, and deployment of ICT in museums. This paper introduces a preliminary version of one such tool, a theoretically informed framework delineating the overall role and place of ICT in the context of museum learning. The purpose of the framework is to orientate researchers and practitioners with regard to main issues involved in supporting technology-enhanced learning in museum settings.

The rest of the paper is organized as follows. The next section discusses some relevant conceptual analyses of meaning making and visitor experience in museum settings. After that the notion of bridging activity contexts is introduced in order to provide a more specific account of learners’ meaning making in museums. Finally, the notion of bridging activity contexts is employed to identify a set of key issues, types of visitors’ engagement, and design tradeoffs in relation to the design of ICT-based support for meaning making in museums.

2. Museums, meaning making, and technology
A key aim of introducing ICT in museums is to enhance visitor experience. But what does “enhance visitor experience” actually mean? In recent years there has been a growing consensus among museum researchers that visitor experience can be adequately described in terms of meaning making [7, 26, 29]. “Meaning making” generally refers to an active interpretation of objects and events, through which interpretation an individual or a group develops a personal meaning, deeply integrated with one’s own values, beliefs, feelings, and aspirations [15, 20].

The notion of meaning making has become popular in educational research, including studies of technology-enhanced learning (e.g., [28, 30]). There are a variety of reasons why researchers find this notion useful. First, there has been a general trend toward constructivist and socio-cultural theories in educational research over the last decades. These theories emphasize the importance of understanding developmental transformation in the learners. Second, the notion of meaning making helps to conceptualize learning experiences and gains that are difficult to
recognize and deal with when using more traditional educational concepts.

Traditional educational research has developed a conceptual and methodological apparatus that supports detecting and measuring new knowledge and skills acquired by the learner. However, this apparatus has a limited scope. For instance, informal learning may produce significant gains that are difficult to anticipate and define explicitly. The learning can result in changes of the learner himself or herself, their values, beliefs, emotions, moral principles, and so forth... These learning outcomes are difficult or impossible to analyze in terms of measurable gains in explicitly defined knowledge and skills.

The notion of meaning making emphasizes the importance of taking into account how the learner changes rather than merely how knowledge and skills pass from the environment on to the learner. Therefore, the notion clearly breaks away from an understanding of learning as a transmission of knowledge from teachers or textbooks to the student. It is hardly surprising that within some of the most passionate anti-transmissional paradigms in educational research, such as transformative learning [4, 18, 31] and computer support for collaborative learning (CSCL) [30, 34] the notion of meaning making has become a key concept.

For similar reasons “meaning making” also became a central concept in museum research. The effects of museum visits on individuals are difficult to pinpoint. While there is a general agreement that such effects can be—and often are—profound, they cannot be scheduled, are difficult to detect, and virtually impossible to document with thorough, verifiable evidence. Observational studies of museum visitors are of limited help: the essence of what happens during a visit cannot be directly inferred from visitors’ external behavior, which is usually not very complex and varied. In addition, visitors’ experiences, arguably, have to do with creating personal meanings rather than the acquisition of pre-existing knowledge and skills. The tacit nature of museum experience and learning is aptly captured by the notion of meaning making, which emphasizes the importance of understanding the “inner work” of imagination, reflection, and interpretation that take place during, and after, a visit.

Meaning making in museums has been the object of analysis in a variety of empirical studies and conceptual explorations. The studies identified a set of general requirements that should be met in order to support meaning making. Some of the key requirements are ensuring engagement, supporting diversities of interests, helping people reveal hidden content, and integrating museum visits into larger-scale events [7, 8, 10, 14, 21, 29]. These requirements identify important aspects of meaning making. However, it is not always clear how exactly these important insights can contribute to making concrete decisions regarding design and deployment of technologies in museums. Engagement cannot be “designed” directly. Designers cannot simply construct a technology-enriched environment that will invoke the desired experience. Technology (and other designable aspects of the setting) can only help create preconditions for engagement by supporting the unfolding dynamics of visitor’s exploration, reflection, imagination, and emotional attachment. To achieve this goal, designers need to have a more concrete understanding of these dynamics and the nature of visitor experience in general.

One of the most influential frameworks in research dealing with ICT in museums in general, and museum learning in particular, is the Contextual Model of Learning, a conceptualization of visitors’ learning experience, proposed by Falk and Dierking [6, 7, 8]. Their framework is based on distinguishing between three different (sub)contexts of visitor interaction: personal context, socio-cultural context, and physical context. The framework has made an important contribution to understanding the nature of museum experience. In particular, identifying these three contexts brings to the foreground the limitations of most museums as places for social and physical interactions.

Arguably, however, the Conceptual Model of Learning does not fully address the needs for conceptual support for design and implementation of ICT in museums. To begin with, the model is rather general. While providing an overall conceptual map of issues related to understanding museum experience, the Contextual Model of Learning needs to be further elaborated and combined with other concepts and research strategies that would ensure a more detailed understanding of the micro-dynamics of visitor’s interactions in museums. As Falk and Dierking observe:

“These three contexts provide the large-scale framework with which to organize the complexity of meaning-making. Within the framework are myriad factors, probably numbering in the hundreds, if not thousands.” [8]

There have been a number of attempts to develop a more fine-grained account of museum experience based on the model. Recently Falk and Dierking presented a more detailed version of their model, which breaks down the three contexts into twelve factors that need to be taken into account when employing ICT in museums [8]. Another elaboration is the 6P model proposed by Kelly [14]. The 6P model identifies six categories, Person, Purpose, Process,
People, Place, and Product, to describe learning in museums.

These recent elaborations, however, do not address another, and more basic, problem with the Contextual Model of Learning: a fragmented view of the context as a whole. The powerful analytic strategy of identifying different types of context in the model is not paralleled by an equally sound synthetic strategy allowing the integration of separate contexts into a coherent whole. Instead, the visitor is assumed to traverse different contexts as if they were different, if overlapping, spaces.

In addition, the model is based on an implicit assumption that context is a “container” for visitor experience and learning: there is an underlying understanding that context is a constellation of “external” factors, which influence learning and experience. As emphasized by Pierroux et al. [22], such an understanding is rather problematic.

The discussion above indicates that despite a substantial progress in understanding meaning making in museums, current conceptual accounts do not provide specific enough guidance for designing and deploying technologies to enhance visitors’ experience. Identifying concrete possibilities for supporting meaning making with ICT requires an understanding of the unfolding process of establishing a connection between individuals and museum artifacts. Such understanding is yet to be developed. Existing theoretical perspectives either “black box” micro-level interactions comprising an individual encounter with an artifact, or provide very detailed analyses of social interactions between people, while paying less attention to how people experience specific artifacts.

The next section presents an outline of a theoretical framework, informed by activity theory, of meaning making in museums that aims to describe, within a coherent conceptual framework, the relationship between learners/visitors, museum artifacts, and technologies.

3. Bridging activity contexts

Activity theory is a conceptual framework originating from Russian psychology of the last century [16], which has become widely accepted in studies of learning and development (e.g., [5]) and has made a substantial contribution to interaction design and related areas [13]. Given that activity theory has been popular in both learning research and interaction design, this approach appears to be especially promising for understanding technology-enhanced learning in museums. A number of studies dealing with information technologies and learning in museums, conducted in recent years have, in fact, been explicitly informed by activity theory [9, 28].

The basic principles of activity theory can be summarized as follows. According to the approach, human activities are: (a) object-oriented, that is, motivated by objectively existing objects, (b) hierarchically structured, spanning a wide range of processes and phenomena, from motivation to skills, (e) mediated by socially developed artifacts, (d) involving continuous transformation between internal and externally distributed processes, as well as individual and socially distributed ones, and (e) constantly developing [13].

An application of these principles to the analysis of digital technologies in museum learning suggests that one of the key aims of using technologies in museums should be bridging activity contexts. When an individual or a group visits a museum and encounters museum artifacts, one can differentiate between at least two activity contexts.

On the one hand, there are contexts of a visitor’s own individual and collective activities. People may visit museums for any number of reasons. Their interests, goals, expectations, etc., as found in visitor studies, are powerful factors influencing museum experience [6, 7]. As already mentioned, however, these are not external factors. They do not exist prior to and independently of a visitor’s activities and experiences in museums. Instead, they are enacted in visitor activities taking place in museums (and, of course, in other activities that may or may not be related to museum visits).

On the other hand, an essential part of any museum visit is revealing the activity contexts that are explicitly or (more often) implicitly represented by museum artifacts. Museum artifacts are crystallized outcomes, by-products, or tools of activities: be it objects of art, material witnesses of historical events, or simply things from the past. The objects are there for visitors to see, but the activity contexts they represent, by necessity and sometimes also by design, cannot be perceived directly.

A fundamental insight underlying the analysis in this paper (and briefly presented earlier in [22]) is that supporting visitors’ meaning making in museums with technology can be accomplished by using the technology to help bridge the activity contexts described above, that is, visitors activity contexts and activity contexts implicitly contained in museum artifacts.

Museums as places for learning and bridging activity contexts pose a number of challenges. In ‘everyday’ learning, the appropriation of artifacts is tightly integrated into activities of the learner. Learning how to use fishing gear, for instance, is likely to take
place within a meaningful social context and be a part of a memorable personal experience. There is a close match between two contexts: the context of the individual or group's interests, aspirations, goals, and challenges, on the one hand, and the context of fishing as a culturally-historically developed form of human practice, with its artifacts, secrets of trade, unwritten rules, and inherent values, on the other hand. In museums as places for appropriating culturally developed artifacts, there is more likely to be gaps between the activity contexts. It challenges designers to provide means of 'gap-closing' between, on the one hand, visitors' activities, which are motivated by more or less clearly defined learning interests, and, on the other hand, the culturally-historically situated activity contexts of the artifacts, which need to be made more explicit.

What are the specific affordances of digital technologies for helping to bridge activity contexts in museum learning? To begin with, it should be noted that digital technologies and authentic museum artifacts play different roles in visitors' activities. The technologies are of secondary importance; their use is subordinated to more central concerns of the visitor. The most important requirement to technologies is that they should support visitors by mediating visitors activities directed at museum artifacts. Using activity theory terminology, the difference between interactive technologies and museum artifacts is the one between "tools" (technologies) and "objects" (authentic artifacts). The difference is made especially obvious by the contrasting expectations with regard to attention resources allocated by the visitor to these two types of objects. Digital technologies, ideally, should become 'transparent' and not distract visitors from authentic artifacts. At the same time, a successful museum experience means concentration on objects; it implies that visitors focus their attention on one or several museum artifacts.

When a museum artifact becomes an object of visitor activities and visitors are attentively, cognitively and emotionally engaged with the artifact, the artifact can be re-contextualized in the visitor activities. By re-contextualization we mean the process of integrating museum objects that had been originally developed for, and used in, certain activity contexts, into the context of a visitor's own activity. Re-contextualization is the process through which visitors appropriate museum objects and their narratives. Designing for appropriation thus requires that both the context of use of the tool and the motivation for using the tool must be made highly relevant [9].

Concrete strategies for using ICT to support re-contextualization of museum artifacts in visitors activities can be framed by Engeström's [5] distinction between downwards contextualization and upwards contextualization.

Downwards contextualization of an artifact means integrating the artifact with lower levels of activity. It may involve customizing the artifact or developing new (or modifying old) low-level units of an activity to make it possible to operate an artifact. Downwards contextualization requires learning (and, sometimes, customization) of various types of artifacts, including digital technologies.

For instance, downwards contextualization of a new mobile device in a museum setting may mean mastering the available functions that are useful for carrying out tasks and learning about museum objects.

The notion also applies to museum artifacts. Understanding how a certain artifact is supposed to be used and, whenever possible, developing a feel for, and even skills of, practical use of an artifact can be considered downwards contextualization. For instance, downwards contextualization of the rolling pin shown in Figure 1 (a) would include an understanding of the tool and its usage in making traditional Scandinavian flatbreads and crisp breads, that is, an understanding of the structure and functionality of the artifact, as well as the physical actions involved.

![Figure 1. (a): Traditional peg rolling pin; (b): Modern-day crisp bread.](image)

Upwards contextualization of an artifact means integrating the artifact with higher-levels of activity, that is, with interests, values, and motives of the person. Successful upwards contextualization of an interactive technology in the context of museum learning would mean setting new higher-level goals (such as new learning objectives), developing more effective and efficient learning strategies, and so forth.
Upwards contextualization of museum artifacts involves developing an understanding of the meaning of the artifact in question in the overall context of learner’s activity. For instance, an encounter with the rolling-pin shown in Figure 1 (a) can stimulate learner’s reflections on such issues as sustainability, gender-specific division of labor in the past, healthy eating habits, and the historical roots of present-day Scandinavian food culture, of which crisp bread and flat bread are some of the most recognizable icons (Figure 1 (b)).

The arguments presented above can be illustrated and further developed using the diagrams shown in Figures 2 and 3. The most basic representation of the context of mediated activity is presented in Figure 2, which depicts a three-way interaction between the subject of activity (S), the object of activity (O), and the means that mediates the relationship between the subject and the object (MM).

**Figure 2. The context of mediated activity: a basic representation**

First, it should be noted that each of the nodes can be opened up and presented as existing in its own (sub) context. The Subject node represents a person with his or her needs, fears and hopes, who lives in a certain culture (or cultures), maintains social relations, and belongs to various groups and institutions. The Object node represents an object as related to other objects and embedded in a certain setting. The Mediating Means node represents a tool, used by the Subject, as related to other tools, actually or potentially available to the Subject. Other people can also be involved in the mediation. Accordingly, Figure 2 shows not only a three-way relation between the subject of activity (S), the object of activity (O), and the means that mediates the relationship between the subject and the object (MM), but also node-related sub-contexts, shown as circles drawn around respective nodes, and the time axis depicted as an arrow marked with a “T”.

A basic representation of mediated activity can be applied to represent both visitor activity context and artifact-related activity context. In case of visitor activity, the object is a museum artifact, and visitor’s interaction with the artifact is mediated by various tools, including ICT. In case of artifact-related activity, a museum artifact is a tool mediating an activity that took place in the past. The subject and object of the activity may not be immediately obvious.

Both activity contexts involve museum artifacts. Museum artifacts provide a link that can be used to bridge the activity contexts. Two activity contexts connected to each other by a common component are presented in Figure 3 as two connected triangles. The upper triangle (VAC) depicts the context of visitor’s (V) activity directed at a museum artifact (MA) and mediated by various mediating means (MM), including ICT. Each of these three nodes is embedded in its own sub-context, which are signified by circles drawn around the nodes. Visitor activity develops over time along the time axis T/V.

**Figure 3. Bridging activity contexts in museums.**

Upper triangle: VAC, visitor activity context (V - visitor; MM - mediating means; MA - museum artifact; T/V - time axis of visitor activity.)

Lower triangle: MAAC, museum artifact activity context (P - people carrying out a past activity; MA/T - museum artifact as a tool mediating past activity; MA/O - museum artifact as an object of past activity; T/MA - time axis of past activity).

The lower triangle depicts the museum artifact-related activity context (MAAC). Museum Artifacts (MA) are objects (MA/O) or mediating tools (MA/T) of activities carried out in the past. These two cases are signified by arrows connecting the MA node of the upper triangle with corresponding nodes of the lower triangle. In many cases visitors can only see an artifact, but not an activity context, that is, who, how, and why it was used in the past.
If MA (such as the rolling pin shown in Figure 1) is a tool used in a past activity, the implicitly present components of the activity context are the subjects and objects (for instance, bakers and bread). Alternatively, MA may represent an object of a past activity. The same artifact can be a tool or an object depending on the activity context. For instance, the rolling pin shown in Figure 1 can be a tool for bakers, but an object for people producing the artifact, e.g., carpenters. When museum artifacts represent objects of activities, there are people carrying out an activity (subjects) and tools that need to be revealed (or imagined) to restore the artifact-related activity context.

A central claim of this paper is that meaning making in museums can be properly characterized as bridging the activity contexts described above; and that supporting such bridging should be a key objective of design and deployment of ICT in museums. By “bridging activity contexts” we mean that through observation, imagination, inquiry and/or physical interactions visitors open up their activity contexts and reach out to meanings, values, and personal experiences revealed through understanding artifact-related activity contexts. These meanings, values and experiences, in turn, may have an effect on the visitor himself or herself and thereby change his or her activity context. Therefore, activity contexts can be bridged successfully if (a) the visitor finds it worthwhile to explore an artifact and its tacit activity contexts, (b) the visitor reveals relevant aspects of an artifact-related activity context by reconstructing it through observation, imagination, and interaction, and (c) visitor exploration of the artifact makes an impact on visitor’s own activity context.

The framework described above is intended to provide support for design and deployment of ICT in museums by helping to identify:

- design sensitivities, that is, drawing attention to key issues and potential trouble spots,
- formats of visitor activities, that is, breaking down the design space of ICT in museums into more manageable sub-spaces corresponding to different types—or formats—of visitor activities that need to be supported with ICT, and
- design tradeoffs, that is, articulating typical dilemmas faced by designers of technology-enabled museum exhibits and strategies for finding suitable solutions and striking balance between conflicting requirements in each individual case.

These issues are discussed in detail in the next section.

4. Applying the framework

4.1. Identifying key issues

First of all, the model depicted in Figure 3 can be used to identify the main issues that need to be taken into account when designing technological support for meaning making in museums. The six nodes and two time axes of the model emphasize the importance of paying attention to:

- the needs, hopes and fears, goals, social relations, and professional backgrounds of museum visitors (V),
- the diversity of tools and other mediating means available to visitors (MM),
- museum artifacts directly experienced by a visitor, as well as other artifacts and the whole physical and social setting of the museum (MA),
- development of visitors’ activities over time, taking into account what happens before and after a visit (T/V),
- support of visitors’ understanding of who was using the museum artifact in the past (P),
- support of visitors’ understanding of why, for what reasons, the museum artifact in question was used in the past (MA/O),
- support of visitors’ understanding of how the artifact in question was used or produced in the past (MA/T), and
- support of visitors’ understanding of unfolding temporal and logical sequences, narratives of using the artifact in question in the past (T/A).

The framework also suggests that technological support for museum learning should include supporting the interaction between the nodes of the visitor activity context (VAC): empowering visitors with personal technologies (V <-> MM), providing means for facilitating communication and collaboration between visitors, as well as visitors and curators (V & sub-context <-> MA & sub-context), and technologically enhancing whole museum exhibits and settings, rather than merely individual artifacts (MM <-> MA & sub-context). These three types of ICT—empowering visitors, facilitating collaboration, and enhancing the setting as a whole—should be integrated with one another, as well as with enabling individual museum artifacts, to achieve the maximum effect.

The main aim of providing the list of key issues above is not to reveal radically new aspects of museum experience or suggest innovative strategies of design and deployment of ICT in museums. Instead, the intended purpose is to support a systematic analysis of
the problem at hand by drawing the attention of people involved in the design, implementation, deployment, or evaluation of ICT in museums to a set of issues that define the problem space, options, and priorities.

4.2. Taxonomy of visitors’ engagement with museum artifacts

Another example of using the proposed framework is outlining a tentative taxonomy of the types of visitor engagement with museum artifacts. The diversity of museum experience is a recurrent topic in museum research, and a number of notions have been developed to provide an account of the diversity. The conceptual framework introduced in this paper allows us to further elaborate upon the types of museum experience. More specifically, the framework suggests that the following four dimensions of visitors’ experience should be taken into account (the references below point to Figure 3):

  Sociality. As mentioned above, visitors (V) can be engaged with museum artifacts individually or together with other people. Accordingly, the first dimension of museum experience is individual vs. collective.

  Goal-orientedness. The interaction between visitors and museum artifacts (V ↔ MA) can be characterized by the extent to which it is driven by the predetermined goals of the visitor. This dimension is defined by two extremes. On the one pole there are cases of totally goal-driven activities: the visitor knows exactly what he or she is looking for, such as finding certain facts for a school assignment. The other extreme is open-ended exploration, when the visitor acts opportunistically and follows the paths he or she finds interesting.

  Museum artifact focus. The primary focus of the visitor can be on a certain aspect of the artifact-related activity context (MAAC). The focus can be on the subjects of past activities: the visitor may try to understand people who used the artifact in the past, their feelings, hopes, values, and so forth. Alternatively, the focus can be on the objects of past activities, on what the people wanted to accomplish. Finally, the focus can be on the operational aspects of the artifact, how it was supposed to be used, what skills it required, and so forth. These three foci,—the subjective focus, the objective focus, and the operational focus, respectively—correspond to the three nodes of the lower triangle shown in Figure 3.

  Engagement modality. Visitor engagement with museum artifacts can take different forms: from perceptual exploration to information inquiries to physical interaction. Information technologies (in a broad sense, including for instance, good old photography) provide an additional layer of virtual engagement, allowing people to perceptually explore images or manipulate virtual replicas of museum artifacts, in addition to (or instead of) direct perception or physical interaction.

The dimensions of visitor engagement described above can define a wide variety of museum visit types. It should be also noted that the specific composition of engagement types within a particular visit can change over time. For instance, a visit could start as a primarily collective goal-driven information inquiry having an objective focus and then transform into an individual perceptual exploration having a subjective focus.

4.3. Design dilemmas and tradeoffs

Any design has to deal with mutually contradicting requirements. Some of these contradictions can be simply resolved by finding a solution that would make a contradiction disappear, but contradictions of a more basic nature cannot be simply resolved once and for all. When dealing with such basic contradictions—or dilemmas—designers have to make tradeoffs. For instance, designers may decide to make a device more portable even though this decision may lead to higher costs and lower performance.

What are the main design dilemmas and tradeoffs when designing ICT for enhancing museum experience? Answering this question requires an understanding of the overall context of introducing ICT in museums and the specific roles of technology in that context. The framework proposed in this paper, and illustrated by the diagram shown in Figure 3, offers support for a systematic analysis of design dilemmas in that particular area. A tentative set of dilemmas identified by using the framework is as follows.

First, implementing ICT in museums requires that mediating means (MM) from one activity context (VAC) be related to another activity context (MAAC). It raises the dilemma of introducing modern technologies vs. preserving authenticity. Second, introduction of ICT also means that VAC becomes more complex and interaction between learner and technology (V ↔ MM) may require more attentional resources. It presents the dilemma of supporting focus on museum artifacts vs. creating distraction by adding new tasks. Third, as mentioned, certain aspects of a museum artifact activity context (P, MA-T, MA-O, and their respective sub-contexts) are usually of primary interest to the learner. It means that there are also issues of secondary importance, which the learner will probably be less interested in learning about. Therefore, designers need to face the dilemma of making experience challenging vs. minimizing visitor’s effort. Fourth, the interaction between visitors and
museum artifacts (V ↔ MA, V ↔ MM → MA) can be affected by the MA context (Fig. 3, the circle around the MA node), which may impose constraints on the interaction. Therefore, the designers face the dilemma of supporting interactivity vs. meeting existing physical and social constraints. Fifth and finally, the “Sociality” dimension of visitor engagement, discussed in section 4.2 above, implies that there is a dilemma of considering museum learning as a personal or social experience. The dilemmas mentioned above are discussed in more detail below.

**Introducing modern technologies vs. Preserving authenticity.** Information technologies in museums often appear to be out of place [22]. Cultural heritage museums cultivate the atmosphere of authenticity, which is what makes them attractive and worth visiting in the first place. Computer terminals may undermine this atmosphere and be perceived as a rude intrusion of modern realities into the carefully created sanctuary for “real, valuable things from the past”. In addition, ICT quickly becomes obsolete and may look second-class, which is likely to aggravate visitors who expect museums to only feature things of high value.

A number of strategies have been used in existing research and practice to make ICT gracefully fit into museum settings. One of the most promising strategies appears to be disguising ICT as magical artifacts [24] or genuine vintage objects, such as an old-fashioned radio [10]. Modern technologies have some common features with crystal balls, scrying pools, and other artifacts known to have the power of showing things that cannot be immediately discerned through “ordinary” perception. Using the metaphor of magical artifacts can be a way to introduce ICT to museums and create right expectations about the functionality of the technology without making exceedingly explicit references to modern realities.

**Supporting focus on museum artifacts vs. Creating distraction by adding new tasks.** When an ICT is introduced to a museum setting, visitors are usually forced to carry out additional tasks, such as learning how to use the technology, operating input devices, monitoring the information displayed on the screen, and so forth. These tasks can distract visitors from experiencing museum artifacts.

The field of interaction design has developed a variety of strategies to make interactive technologies more transparent and minimize their interference with other everyday tasks. These strategies include the use of “perceived affordances”, employing different modalities for carrying out different tasks, and so forth. In recent years these more traditional strategies have been complemented with novel design solutions, such as projecting images generated by ICT directly on museum artifacts and thus ensuring a single focus of visitors’ attention (e.g., [24]).

A promising strategy of dealing with distraction caused by ICT, while capitalizing upon the advantages of the technology, is employing ICT for (a) keeping record of a museum visit and (b) using these “trails” of the visit at a later time to reflect upon the evidence, ideas, and experience resulting from the visit [33].

**Making experience challenging/ Minimizing visitor’s effort.** Enhancing museum experience often means offering visitors challenging tasks. However, visitors apparently do not want all tasks to be challenging. Some tasks requiring a substantial effort are perceived as getting in the way and undermining the whole experience. Therefore, designers should selectively use ICT to make some tasks more challenging, while making other tasks less demanding.

The technology-enhanced exhibition dedicated to Shackelton’s Antarctic expedition in the American Museum of Natural History1 is an example of a successful use of ICT for selectively changing the difficulty of visitor tasks. The exhibition reconstructs the extremely difficult conditions in which the explorers navigated their lifeboat through the sea by measuring the position of the sun. The exhibition employs ICT in two ways. First, computers control the dynamic image projected on the surrounding walls to simulate high waves and low visibility. The projected image has been deliberately designed to make it difficult for the visitors to make a sighting and navigate the boat. Second, technology is employed to help visitors use an authentic sextant, by providing step-by-step instructions and, through processing information received from embedded sensors, making all necessary calculations, which would otherwise take considerable time, effort, and skill.

The Shackleton exhibition example suggests that when making engagements with museum artifacts more or less challenging designers should take into account visitor’s focus on one of the aspects of the museum artifact activity context (MAAC, see Figure 3). In Shackleton’s expedition case the visitor’s focus is intended to be on people and objects rather than mediating means (P and MA-O, rather than MA-T, see Figure 3). Accordingly, ICT was used to make the former more challenging and the latter less challenging. If the intended visitor’s focus was on a mediating tool, for instance, the visitors were expected to be predominantly interested in learning the authentic skills of using 20th century sextants, the implementation of ICT could be completely different.

A variation of the design dilemma of selectively adjusting the difficulty of visitor’s tasks is **stimulating**

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1 http://www.amnh.org/exhibitions/shackleton/exhibition.html
curiosity vs. providing explanations. Currently one of the main applications of ICT in museums is providing visitors with information about artifacts and exhibits. Traditional museum labels can convey only limited amount of information, and information kiosks or mobile guides can help compensate for the limitations. However, an opposite approach—that is, removing artifact labels altogether—can also enhance visitor experience. This approach has been successfully employed, for instance, in the Hunt museum in Limerick [10].

Should designers ensure an easy and convenient access to information or prevent visitors from getting immediate answers, thus stimulating curiosity? As discussed above, there is a diversity of types of visitor engagements with artifacts. Some of these types would benefit from concealing information from the visitor, while others will not. Identifying the types relevant to a concrete case may help define the most appropriate design strategy.

Supporting interactivity vs. Meeting existing physical and social constraints. Arguably, people could be more engaged with museum artifacts if they had chance to physically interact with them. However, neither physical nor social constraints of most museums encourage physical interactions. Museum artifacts are usually too valuable to expose them to tear and wear associated with everyday physical handling. In addition, museum settings are often crammed with objects and do not have enough space for physical activities. Finally, physical interaction with artifacts can potentially disturb other visitors, who may come to the museum looking for a place for a quite contemplation.

A key rationale for introducing ICT to museums is overcoming the above limitations of museum settings and making museum exhibits more interactive. One of the most promising strategies to support interactivity is using digitally enhanced replicas of genuine artifacts. Even regular, not technologically enhanced, replicas can considerably increase interactivity. Many museums provide visitors with convincing copies of authentic artifacts, which can be physically explored. Digital enhancement of artifacts, for instance with embedded RFID tags, adds a new semiotic layer of interactivity. The tags can be recognized by other devices, and mobile guides can help compensate for the limitations.

In addition, RFID tags, adds a new semiotic layer of interactivity. The tags can be recognized by other devices, and mobile guides can help compensate for the limitations.

5. Conclusion

The point of departure for the analysis in this paper is an acknowledgment of the need for a conceptual framework placing ICT in museums in the context of visitor activities. Such a framework could aid analysis, design, evaluation, and deployment of ICT in museums by supporting a systematic exploration of the potential of ICT for enhancing visitors’ experience. The paper introduces an understanding of museum experience as bridging activity contexts, and presents an initial attempt to identify some key issues, visitor experience types, and design tradeoffs relevant for designing ICT to support meaning making in museums.

The aim of the paper is to illustrate the potential of the bridging activity contexts framework as an analytical tool for interaction design. Both the current formulation of the framework and conclusions made in the paper are preliminary; further research is needed to develop the framework and elaborate its implication for interaction design in museums.

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7. References

