Micro-augmentations: situated calibration of a novel non-tactile, peripheral museum technology

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ABSTRACT
Micro-augmentations provide novel ways to interact directly with the past. This is a new concept that uses minimum stimulation to achieve maximum effects in spaces of cultural heritage. We experiment with new implicitly interactive and almost transparent museum technologies to create a holistic emotional visitor experience and solve a number of museum problems (i.e. misconceptions, intra-group communications, and visitor engagement). The paper presents the rationale for the design decisions, as well as the technical challenges faced during implementation. Audio micro-augmentations were firstly used at the UCL Grant Museum of Zoology. Initial user testing data from the system's calibration phase at that museum revealed the entertaining and learning potential of the application, together with issues for future development.

Categories and Subject Descriptors
H.5.2 [**Information Systems**]: Multimedia Information Systems – *artificial, augmented, and virtual realities.*

General Terms
Design, Experimentation, Human Factors

Keywords
Augmented reality, museum

1. INTRODUCTION
Although a number of researchers are involved in the making of museum technologies, funding is spent, knowledge is collected, conferences are organized, during user evaluation a user statement challenges many current assumptions about visitors' experiences: "I don't really like technology in museums." (from real user evaluation, [8]). Is technology then really necessary in spaces of cultural heritage? If yes, under what circumstances? Looking further into the subject, it became obvious that although different spaces are called museums, there are significant differences between museum types. In museums of both high objectness (presence of important physical objects, [16]) and high museumness (extend to which a museum fulfills the stereotypical expectations of visitors, [2]), technology is viewed as unnecessary or even inappropriate. Visitors do not simply go to museums to perform a certain activity (e.g. learning), but they are rather seeking a holistic experience [20], in line with the aesthetics of the artifacts presented. In museums of exhibits of high historical and aesthetic value, like an archaeological museum, the use of imposing technology could be perceived as unsuitable. Many museums of such characteristics (e.g. British Museum, National Archaeological Museum of Athens, Vatican Museums, etc.) have decided not to use imposing technological applications in their premises, avoiding the aesthetical contradictions but also missing out on the possible benefits of technology with regards to covering different visitor needs (i.e. learning, socialization, entertainment).

In addition, museums also face the common problem of visitor misconceptions. Museum misconceptions are difficult to handle, since curators cannot know exactly how different museum themes are perceived by the visitors, what visitor might know prior to their visit and how strong these misconceptions are. In addition, previous studies have also found that adults often propagate their own misconceptions to children [7]. Although different visitors might have different misconceptions, there are certain themes that seem to reoccur in museums. Usually museum curators are aware of the common misconceptions and look for possible solutions. Changing visitors' misconceptions can be a more challenging and demanding job than teaching them new knowledge. However, there is clear evidence that museum technologies targeting visitor misconceptions can be a valuable tool in this process with significant results [6].

Furthermore, people rarely visit museums alone. Once in a group, the possible isolating powers of technology should be avoided and solutions to enhance intra-group communication need to be employed. Past research has also shown that one of the main reasons groups, like friends or families, visit museums is intra-group communication [5]. In particular, parents try to assist the children's museum experience and engage in educational dialogue [22]. For the above reasons, technologies for cultural heritage should not simply focus on proving information on museum content but should also consider issues of increasing group communications and provide opportunities for effective interaction.

In this context, the present work focuses on an implicitly interactive, non-adaptive, supporting implicit narrations, almost transparent application that causes emotional arousal and provides an unstructured museum experience. Deciding not to follow the common path of interactive applications that support explicit narrations to provide a structured museum experience, micro-augmentations were employed (to be explained below), a new concept that will hopefully add value to the museum experience as a whole. Therefore, novel interfaces for cultural heritage are explored, in an attempt to provide a holistic aesthetic experience to the visitor and to experiment with alternative ways to interact

with the past. Micro-augmentations are proposed here are as a new approach in interacting with the past and have three main targets: a. to provide an emotional holistic museum experience, by triggering visitors' curiosity, b. to provide a solution to common museum misconceptions and c. to increase intra-group and possible inter-group communication within the museum.

2. MICRO-AUGMENTATIONS

Augmented Reality (AR) is a good way to animate exhibits and previous studies showed positive results from its use in museums [10]. However, AR applications still face a number of usability issues (e.g. size of devices, positioning of the device in front of exhibits, etc.) [9]. In this light and in line with the previous decision to focus on non-intrusive, almost transparent applications, it was decided that the application would only use sound effects, provided to the users through technology invisible to them.

Wishing to test the hypothesis *Less is More*, Micro-augmentations are introduced here, as a new concept and a tool for the study of the effects of minimum stimulation in the creation of museum experiences. A micro-augmentation is a minimum meaningful stimulus provided to the user, through a non-intrusive application. Technology interpretations are kept to a minimum level, since there are no functions that the user should learn and no interactive elements. Content interpretations are also at a minimum level, since the informative element is on the least possible value. Micro-augmentations are location specific and they support direct visitor-exhibit inner dialogue (please, see examples below). The stimuli are also at the minimum conscious perception level, since they move between perception and intuition. For example, any sound used should be very low. The user cannot be sure whether s/he heard it or not. This uncertainty leads to emotional arousal [30]. The informative gap might also increase learning motivation and visitor communications.

In order to enhance the user experience, micro-augmentations need to be designed based on a complete analysis of human factors, implied by the visitor activity in museums of different thematic content and size, with different types of visitors (e.g. families, schools, people visiting alone). In the case study to be presented here, visitor activity of the museum was recorded and analyzed based on onsite observations of visitor behavior and data from interviews with the museum manager (please, see the case study for more information).

In a hypothetical scenario of use, a couple walks in front of an animal skeleton in a Zoology museum. One person hears an animal sound and the other person hears a gun shot. They both engage in a conversation as to what they heard and what that might mean. Similarly, a family walks in front of the dodo bones. The text provided is difficult for the parents to explain but the children are listening to occasional squawks, rustlings and rain-patters of a bird in a forest. Only one member of the group hears the sounds that only last for a few seconds. Sounds are not repeated if the person passes from the same spot, as multiple sound stimuli are associated to each exhibit. Sounds are randomized with respect to the kind of sound and the intervals between them.

Micro-augmentations are based on the careful selection of stimuli (in the case study below, there are examples of stimuli used). Research suggests that the messages used in museum applications should be in a hierarchical order going from the most important to the least important [5]. Sounds are selected not solely on the basis of creating an ambience but attempting to provide the visitor with meaningful stimulation that could trigger different cognitive and emotional processes. For example, as it will be also explained further in the case study below, since it is not clear how animals died in a Zoology museum, a relevant sound to use, would be a gunshot. Similarly, sounds can carry a minimum informative element that could make visitors wonder what it was and why it was used. Furthermore, the selection of stimuli for micro-augmentations also needs to be based on findings from cognitive psychology, since they target emotional arousal. Specific sounds need to be carefully selected (e.g. tonalities to be used are As-dur, A-dur, H-dur, E-mol), based on their relations to particular emotional states (happiness, great energy, dreaminess), using findings from psychological research [27].

In the case study presented here, after curator interviews, the stimuli were chosen based on key learning elements. The case study below demonstrates how micro-augmentations use the minimum informative element in a particular museum space.

2.1 Concept Rationale

Micro-augmentations focus on different aspects of technology for cultural heritage and follow an alternative path. The special characteristics of micro-augmentations (i.e. implicitly interactive, non –adaptive, transparent, etc.) are presented in this section together with the rationale for those decisions.

Implicitly interactive application: Contemporary museums use different applications for their purposes, which can be imposing, interactive, adaptive, providing a highly structured experience, having clear learning goals, etc. The engaging powers of technology were considered to be beneficial for museums and research showed that visitor evaluation was positive [35]. However, reports of the possible distraction powers of interactive technology in museums emerged [9]. In addition, it seems that interactive technologies can socially isolate their user in a museum [15]. Furthermore, interactivity was found to be unrelated to the effectiveness of exhibitions and the engaging powers of artifacts and although in certain museum types (e.g. science museums) it might add to the experience, it does not seem to be a necessary element of exhibition's success [34]. A recent study revealed that although interactive technology might increase the time visitors spend in a museum, it does not necessarily increase the knowledge they gain and visitors seem to prefer a generic approach to information, not tailored to specific interests [20]. Thus, the actual benefits of interactive applications have been lately questioned [37]. Although interactivity is fine under certain conditions, the degree of interactivity required in different museums is worth studying further. Should alternatives to explicitly interactive applications be explored for museum of different types?

Non-adaptive application: Adaptive technologies are also popular with museum professionals. However, findings are inconclusive. Despite the obvious benefits for providing the user with information that s/he perceives as relevant, according to specific interests, learning characteristics, personality traits, situational factors, etc., the process of adaptation is rather demanding. The multi-factorial nature of adaptivity makes the task challenging and researchers have encountered numerous issues (e.g. amount of control provided to the visitor [25], ineffective use of time [14], etc.). Especially in spaces of cultural heritage, previous research has found that adaptive technologies providing personalized

information (either content or presentation style) are not always appreciated by the users [13]. Therefore, although adaptive technologies could add to the individual's museum experience and there are certain attempts to increase their effectiveness [3], there is still room for improvement. Within the present framework of micro-augmentations, adaptivity is not considered at this point. Being at the beginning of a highly novel research approach, adaptivity would significantly increase the complexity of the initial design and implementation. At the present phase, micro-augmentations will provide a pre-orchestrated experience to the user. However, future development would not dismiss adaptive solutions, especially regarding volume that could adapt to the density of the visitors per room and the age of visitors.

Implicit narrations: Museum interpretations are a complicated problem, museum professionals face. Museum space and architectural elements, exhibition layout, explanatory text, etc. are not interpretation free. They all show previous more or less conscious decisions made from a number of professionals before the visitor is presented with museum content. It is therefore, pre-decided what is worth seeing, what is important, what are the similar characteristics between artifacts and so on. However, previous research has shown that visitors are interested on different aspects of artifacts, based on their specific personality traits. In particular, there are indications that situation independent cognitive factors (i.e. specific ways to approach and process information) seem to be correlated with museum interests, since visitors of different cognitive styles required different information about the same exhibition (some wanted to learn more about history, others about functionality and others about aesthetics) [3]. Although it is not possible to change the physical layout of exhibitions according to individual interests, we can try to eliminate interpretation elements when we provide information through technology. In addition, technology is not a neutral medium [17]. Its very use carries a number of interpretation problems and changes the nature of the experience [21]. Users do not always use applications the way intended by designers. Especially, when the target group is as heterogeneous as museum visitors, the way different applications will be understood is almost unpredictable [24]. Considering the above, it was decided that technology imposed interpretations should be kept at a minimum level, in an attempt to provide the visitor the necessary freedom for the creation of personal meaning. In line with our decision for non-interactive and non-adaptive technology, it was clear that technology should not interfere to the visit at any level (although traces of interpretations are always present, since behind the applications there are designers' decisions) and the content should also be at a minimum level. As explained below, content was kept at a minimum informative level and no visual information was used, as an attempt to simply trigger a reaction without providing extra information. Being a central hypothesis in micro-augmentation, the effects of this minimum stimulation will be extensively explored in our future studies.

The issues of museum interpretations lead to the subject of museum narratives. Explicit narratives, used by most museum applications, can narrow the viewing angle and impose certain interpretations. This practice can assist the visitor to focus on specific learning issues, but is also restrictive in allowing the creation of different personal experiences. Many museum researchers view the museum experience as a dialogue between the visitor and the exhibits, in which pre-knowledge and individual past experiences play a crucial role in meaning making [32]. Furthermore, personal meaning is constructed in museums regardless of implicit or explicit narratives [36]. Thinking that explicit narratives can strengthen pre-existing exhibition interpretations, the main question formed was: How can we assist a direct dialogue between the visitor and the exhibit? Moving away from explicit narratives, affective cues to trigger implicit narratives are investigated.

Almost transparent application: As explained above, visible museum technologies might not be suitable for many museums and certain visitors. Previous research also shows that the use of technology involves a number of tasks from the visitor. Visitors wonder what the application is, what it does, how it is used, if it is useful to them and so on [29]. Technology in this light can be viewed as distractive and intrusive. Thus, it was decided that micro-augmentations would be almost transparent and will not require any user actions. In fact, micro-augmentations' devices would be almost invisible to the visitors.

Unstructured experience: Although applications providing structured experiences, especially in regards to route suggestions, have been effectively used in museums [31], research shows that following specific paths in museums is not a straight forward task [3]. A random viewing order also reduces the degree of existing interpretations in a museum space, since each visitor might take a different path. In addition, highly structured resources can be viewed as intrusive [23] and although they might have positive outcomes on a cognitive level (increase some types of learning), can also lower the overall experience [11]. Therefore, we will concentrate on stimuli that do not need to be connected to each other and will be only single exhibit specific.

Emotional arousal: Unlike other museum applications with a cognitive/intellectual orientation and clear goals (usually learning goals), the present work wished to investigate the role of emotions in the overall museum experience. Although minimum informative elements were used, the focus remained on emotional arousal and the possible ways this could be beneficial to the museum visit. Research shows that despite the fact that emotions and reason are complementary [18], emotions' role in different applications has been under-researched [12]. Emotions can trigger a number of cognitive processes, like motivation for action [26], positive learning outcomes [19], increase in satisfaction levels [33], since they involve affective, cognitive, physiological, motivational, and expressive components [28]. One way to cause emotional arousal is to increase curiosity, through missing information, and create an information gap [1]. When information gap and surprise elements were used in museum applications, research showed that not only curiosity increased, but also intra-group communication was significantly enhanced [4]. Therefore, through a careful selection of sounds, the present work wished to explore further the role of emotional arousal in museum visits.

3. METHOD

Micro-augmentations were used and tested at the UCL Grant Museum of Zoology (http://www.ucl.ac.uk/museums/zoology). The Grant Museum of Zoology is a unique museum, not simply because it is the only remaining university zoological museum in London, but also because it houses a rare collection of 67,000 specimens. Furthermore, the fact that it was founded in 1828 as a teaching collection, by Robert Edmond Grant, the first Professor of Zoology and Comparative Anatomy in England, makes it a place of great historical importance.

An interview with the museum manager, as well as a visitor observation session, allowed the collection of user requirements. The interview revealed common museum misconceptions (e.g. it is not clear to visitors how these animals died) and important exhibits that could be further highlighted. In addition, during visitor observations it was also found that important exhibits go unnoticed and visitors tend to gather at the centre of the museum. Micro-augmentations were employed to provide solution to the above problems.

For this initial study, one exhibit was micro-augmented, the elephant skull. We implemented our solution with the use of a sensor, which would track when a visitor approached the exhibit, and of a directional sound device, which would emit associated sounds towards the visitor. For the elephant skull, the associated sound library consisted of elephants trumpeting, elephants in agony and rifle gunshots (to relate to the way this elephant had died), heart beats (to relate to another item in the museum associated to the elephant skull: an elephant heart), jungle ambiance (including sounds of birds and monkeys). As the sensors detected visitors, a random sound was triggered, during a short period of time (between 2-8 seconds), within a range of a meter from the exhibit's adjoining wall. The sound effects were triggered just once to avoid distracting repetitions.

Thus, the implementation of micro-augmentations wished to study the following hypotheses: 1. Micro-augmentations will trigger visitor emotional responses and especially their curiosity, 2. Visitors exposed to micro-augmentations will have fewer common misconceptions regarding the augmented exhibits, and 3. There will be an increase in intra-group communication. However, being a novel approach, the implementation of micro-augmentations faced numerous technical challenges, worth describing. The technical aspects of this case study are presented in the next section.

4. RESULTS – CALIBRATION {HASE USER DATA

While implementing the installation at the Grant museum, a number of visitor interviews revealed the project's potential and possible improvements. Together with interview data from 17 museum visitors, randomly selected, four experts were also invited to provide specialized information. Since this was a calibration phase, the duration and the volume of sounds varied, resulting in some visitors hearing (second implementation phase) and some not hearing the sounds (first implementation phase). The descriptive statistics, in regards to the age of the 21 participants are: mean 30.4, median 27, standard deviation 11.9. Most participants were visiting in a group of either family or friends and only 3 out of the 17 visitors of the general public were visiting alone. In addition, 11 out of 17 participants heard the sounds, but only 6 noticed the set-up (speakers, wires, etc.). Elements from the Achievement Emotions Questionnaire [26] were incorporated in the interview questions in order to capture perceived emotional arousal. Thus, from the 10 visitors that heard the sounds and reported their emotions, 6 indicated that they felt curious about the sounds and wanted to explore more. Of those who heard the sounds, 8 were satisfied with the duration of the sounds and 5 were satisfied with the volume. 2 participants wanted longer duration, 1 shorter, and 6 wanted more volume. Some people reported that because of the application they read the exhibit label, although normally they do not, indicating that there might be a good learning potential. In particular, a couple found the application a "great learning tool for kids". A mother visiting with her 2 children mentioned that the application increased the intra-group communication, triggered family discussions and made them all read the exhibit label. She ended her interview by saying: "Loved it". Other participants wanted more exhibits to be micro-augmented. In addition, 3 participants wanted the sounds to be louder in order to surprise the visitor ("Use loud and short sounds to surprise the visitors and change exhibit lighting", "Use louder sounds to surprise the visitors"). 6 participants reported that the application was entertaining ("It is a cool application"; 2 participants mentioned, "The application creates a certain atmosphere/ambiance". One participant wanted the application to be combined with informative material to be placed next to the augmented exhibits (i.e. iPad with additional information). In regards to the common museum misconceptions about the animals (visitors do not know that most of the animals were hunted), 10 out of the 21 participants realized that these animals were hunted. Finally, one group of friends after the interview, went back to try the application again for 2 more minutes. Notably, another group of friends also returned after they were interviewed because they had not heard the sounds and tried it again for 10 minutes. Later that day they came back and brought another friend to try it out, too.

The invited users, were two expert visitors (frequent museum goers, they have visited the Grant museum several times), one Human Factors expert and one Media expert. Two of the experts heard the sounds and the other two were not sure (they thought that they might have heard high pitched bird sounds). All of the experts wanted the sounds to last longer and be louder. The expert visitors said that because of the application they stayed longer in front of the augmented exhibit, than they usually would have. The media expert also asked for louder sounds in order to surprise the visitors. The human factors expert found the application highly usable and mentioned that it made her feel curious and it also brought back memories from traveling. Finally, two of the expert users found an entertainment potential of the application.

5. DISVUSSION AND CONCLUSIONS

Despite the limited data available from users during the calibration phase, certain aspects were particularly interesting. The fact that some users retried the application and even called friends to try it was very promising. Moreover, the suggested approach and the absence of direct interaction with the technology implies minimum usability issues. Micro-augmentations require a minimum whole body interaction, since the visitor only needs to cross the line to trigger the sounds effects. Although unintentional at first, users seem to enjoy experimenting with the application and try to cross again and again through different places. Micro-augmentations though user testing remained almost invisible for the majority of the participants that did not seem to notice the source of the sounds. Although some visitors reported they had noticed the installation, they could have misidentified the sound source (a separate video installation was close to the exhibit).

In regards to the project's three main targets, there is evidence from the calibration phase, that micro-augmentations can be used to enhance the museum experience as a whole, by surprising the visitors and triggering their curiosity. Indeed elements of emotional arousal were already observed during the interviews; however, our future work will focus on measuring emotional arousal from physiological responses as well (i.e. galvanic skin response).

In addition, there is evidence that intra-group communication (inter-group communication was not observed at this phase) can be also increased. Especially, regarding group visits micro-augmentations could be used to enhance intra-group communication (e.g. we found that it increased intra-group communication of the family participating and other group visitors). Visitors seemed to engage in further testing of the application and the between them communication seem to be facilitated.

However, only about half of the participants realized the true cause of death of the animals. From the available data is not clear whether they knew this information from before, or micro-augmentations made them realize it (one of the sounds used was a gunshot). Since museum misconceptions seem to remain for a few visitors, this finding could be explained due to the fact that during the first implementation phase, visitors did not clearly hear the sounds. Certainly, during future user testing, new data will hopefully clarify these issues further and the main project hypotheses will be tested. Since available data come from the calibration phase, once the system is fully functional, further tests will be scheduled.

In addition, there were also indications that there might be a learning potential of the application, since a few people reported that they read labels although they normally do not. The learning potential will be further explored, since it is also linked to the emotional arousal element of micro-augmentations.

The valuable data collected through the calibration phase, enabled the improvement of the sounds used and revealed the need for an audio mapping of the museum acoustics. For example, due to sound reflecting on the different surfaces, the speakers need to be further adjusted. In the next experimentation phase enriched sound libraries will be used and more exhibits will be audio augmented. In addition, among the planned future development will be the experimentation with visual micro-augmentations. The scenarios already developed for the Grant museum include skin appearing quickly on the skeleton, eyes appearing and moving, etc. Despite the inevitable calibration phase problems, due to the highly novel nature of the system and the technical challenges, this work in progress suggests that museums and visitors might be ready for alternative ways to interact with the past. Thus, we have started to develop new design principles that suggest a paradigm shift in the field of interactive museum installations. In our first attempt to implement micro-augmentations, despite the problems faced, the research team observed positive public responses to the system. Micro-augmentations were proposed here as a means to explore the appropriateness of interactive and personalized technologies in spaces of cultural heritage. Perhaps moving away from explicit and direct approaches might allow researchers to investigate new fields that involve intuitive methods, emotional stimulation through careful selection of stimuli, etc. Possible positive results can provide support for a paradigm shift in technologies for spaces of cultural heritage. Finally, the issues to consider further are: 1) the place of personalized applications and their appropriateness in certain spaces and situations, 2) the shift of the main focus from the unique aspects of the user, to the unique characteristics of exhibit and 3) the way to provide holistic emotional experiences in cultural heritage with long lasting effects.

6. REFERENCES

[1] Alwitt, L.F. (1994). Maintaining Attention to a Narrative. Advances in Psychology Research, 18, 99-114.

[2] Antoniou, A., & Lepouras, G. (2009). Meeting Visitors' Expectations: The Perceived Degree of Museumness. In J. Cordeiro, B.B. Shishkov, A. Verbraeck, & M. Helfert (Eds.), Proceedings of the first international conference on computer supported education (pp. 187 – 193). Setubal, Portugal: INSTICC Press.

[3] Antoniou, A. & Lepouras, G. (2010). Modeling visitors' profiles: A study to investigate adaptation aspects for museum learning technologies. Journal of Computing and Cultural Heritage, 3 (2), Article 7, 19 pages. doi:http://doi.acm.org/10.1145/1841317.1841322

[4] Callaway, C., Stock, O., Dekoven, E., Noy, K., Citron, Y., & Dobrin, Y. (2011). Mobile drama in an instrumented museum: inducing group conversation via coordinated narratives. In Proceedings of the 16th international conference on Intelligent user interfaces (IUI '11) (pp.73-82). New York: ACM. doi: http://doi.acm.org/10.1145/1943403.1943416

[5] Caulton, T. (1998). Hands-on Exhibitions. London: Routledge.

[6] Chang, M., Chang, A., Heh, J.S., & Liu, T.C. (2008). Context-aware learning path planner. WSEAS Transactions on Computers, 7 (4), 316-325.

[7] Colombo P.D., Aroca, S.C., & Silva, C.C. (2010). Daytime School Guided Visits to an Astronomical Observatory in Brazil. Astronomy Education Review, 9 (1), 7 pages doi:http://dx.doi.org/10.3847/AER2010017

[8] Cosley, D., Lewenstein, J., Herman, A., Holloway, J., Baxter, J., Nomura, S., Boehner, K., & Gay, G. (2008). ArtLinks: fostering social awareness and reflection in museums. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '08) (pp.403-412). New York: ACM. doi:10.1145/1357054.1357121

[9] Damala, A., Cubaud, P., Bationo, A., Houlier, P., and Marchal, I. (2008). Bridging the gap between the digital and the physical: design and evaluation of a mobile augmented reality guide for the museum visit. In Proceedings of the 3rd international conference on Digital Interactive Media in Entertainment and Arts (DIMEA '08) (pp.120-127). ACM, New York: ACM. doi:10.1145/1413634.1413660

[10] Damala, A., Marchal, I., & Houlier, P. (2007). Merging Augmented Reality Based Features in Mobile Multimedia Museum Guides. In A. Georgopoulos (Ed.), Proceedings of the CIPA, Anticipating the Future of the Cultural Past (pp.259-264).

[11] DeWitt, J., & Storksdieck, M. (2008). A Short Review of School Field Trips: Key Findings from the Past and Implications for the Future. Visitor Studies, 11(2), 181-197. doi:10.1080/10645570802355562

[12] Dirkx, J.M. (2006). Engaging emotions in adult learning: A Jungian perspective on emotion and transformative learning. New Directions for Adult and Continuing Education, 109, 15–26. doi:10.1002/ace.204

[13] Filippini-Fantoni, S. (2003). Personalization through IT in museums. Does it really work? The Case of the Marble

Museum Web-site. In X. Perrot (Ed.), Proceedings of the International Conference on Hypermedia and Interactivity in Museums (ICHIM) (pp.1-16). Paris: Ecole du Louvre.

[14] Findlater, L., & McGrenere, J. (2004). A comparison of static, adaptive, and adaptable menus. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '04) (pp.89-96). New York: ACM. doi:10.1145/985692.985704

[15] Heath, C., & vom Lehn, D. (2002). Misconstruing interactivity. In M. Hinton (Ed.), Proceedings of Interactive Learning in Museums of Art, London: Victoria and Abert.

[16] Heumann – Gurian, E. (1999). What is the Object of this Exercise: A meandering exploration of the many meanings of objects in museums. America's Museums' issue, 128 (3), 163-183.

[17] Hlynka, D. (1996). Postmodernism. In D. Jonassen, (Ed.), Handbook of Research in Educational Technology. New York: Macmillan. Retrieved from www.umanitoba.ca/centres/ukrainian_canadian/hlynka/papers/postmodernism.html

[18] Imel, S. (2003). Effect of Emotions on Learning in Adult, Career, and Career-Technical Education. ERIC Trends and Issues Alert, 43, 4 pages.

[19] Izard, C.E. (1991). The Psychology of Emotions. New York: Plenum Press.

[20] Kuflik, T., Stock, O., Zancanaro, M., Gorfinkel, A., Jbara, S., Kats, S., Sheidin, J., & Kashtan, N. (2011). A visitor's guide in an active museum: Presentations, communications, and reflection. Journal of Computing andCultural Heritage, 3 (3), 25 pages. doi:http://doi.acm.org/10.1145/1921614.1921618

[21] Leblanc, S., Saury, J., Seve, C., Durand, M., & Theureau, J. (2001). An analysis of a user's exploration and learning of a multimedia instruction system. Computing Education, 36 (1), 59-82. doi:10.1016/S0360-1315(00)00053-1 http://dx.doi.org/10.1016/S0360-1315(00)00053-1

[22] Leinhardt, G., & Knutson, K. (2004). Listening in on museum conversations. Walnut Creek, CA: AltaMira Press.

[23] Mortensen, M.F., & Smart, K. (2007). Free-choice worksheets increase students' exposure to curriculum during museum visits. Journal of Research in Science Teaching, 44 (9), 1389-1414. doi:10.1002/tea.20206

[24] Oudshoorn, N., & Pinch, T. (2003). How users matter: The Co-Construction of Users and Technology (Inside Technology). Cambridge, MA: MIT Press.

[25] Papanikolaou, K., Grigoriadou, M., & Kornilakis, H. (2001). Instructional and Interface Design in an Adaptive Educational Hypermedia System. In A. Lionarakis (Ed.), Proceedings of Human-Computer Interaction 2001, Panhellenic Conference with International Participation (pp.223-228). Patras, Greece: Hellenic Open University Press.

[26] Pekrun, R., Goetz, T., Frenzel, A.C., Barchfeld, P., & Perry, R.P. (2011). Measuring emotions in students' learning and performance: The Achievement Emotions Questionnaire (AEQ). Contemporary Educational Psychology, 36, 36-48. doi:http://dx.doi.org/10.1016/j.cedpsych.2010.10.002

[27] Sapozhnikova, K., & Taymanov, R. (2009). Multiparametric Measurements of Emotions. In Proceedings of the XIX IMEKO World Congress Fundamental and Applied Metrology, (pp.1180-1185). doi:10.1.1.415.5512.

[28] Scherer, K. (2009). The dynamic architecture of emotion: Evidence for the component process model. Cognition and Emotion, 23, 1307–1351. doi:10.1080/02699930902928969

[29] Sengers, P.J., & Gaver, B. (2006). Staying Open to Interpretation: Engaging Multiple Meanings in Design and Evaluation. In Proceedings of the 6th conference on Designing Interactive systems (pp.99-108). New York: ACM. doi:10.1145/1142405.1142422

[30] Singer, T., Critchley, H.D., & Preuschoff, K. (2009). A common role of insula in feelings, empathy and uncertainty. Trends in Cognitive Sciences, 13 (8), 334-340. doi:10.1016/j.tics.2009.05.001

[31] Specht, M., & Oppermann, R. (1999). User Modeling and Adaptivity in Nomadic Information Systems. In Proceedings of the i3 Annual Conference: Community of the Future (pp.65-68). Retrieved from http://wenku.baidu.com/view/d9e42341a8956bec0975e324.html

[32] Stainton, C. (2002). Voice and images: Making connections between identity and art. In G. Leinhardt, K. Crowley, & K. Knutson (Eds.), Learning Conversations in Museums (pp.213-257). London: Erlbaum.

[33] Um, E.R., Song, H,. & Plass, J. (2007). The Effect of Positive Emotions on Multimedia Learning. In C. Montgomerie, & J. Seale (Eds.), Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications (pp.4176-4185). Chesapeake, VA: AACE.

[34] Wakkary, R., Hatala, M., Muise, K., Tanenbaum, K., Corness, G., Mohabbati, B., & Budd, J. (2009). Kurio: a museum guide for families. In Proceedings of the 3rd International Conference on Tangible and Embedded Interaction (TEI '09) (pp.215-222). ACM, New York: ACM. doi:10.1145/1517664.1517712

[35] Walczak, K., Wojciechowski, R., & Cellary, W. (2006). Dynamic interactive VR network services for education. In Proceedings of the ACM symposium on Virtual reality software and technology (VRST '06) (pp.277-286). New York: ACM. doi:10.1145/1180495.1180552

[36] Walker, K. (2006). Story structures: Building narrative trails in museums. In G. Dettori, T. Giannetti, A. Paiva, & A. Vaz (Eds.), Technology-mediated narrative environments for learning (pp. 103-114). Rotterdam: Sense Publishers.

[37] Whitcomb, A. (2006). Interactivity: Thinking beyond. In S. Macdonald (Ed.), Companion to Museum Studies (pp.353-361). Malden, Massachusetts: Blackwell Publishing.