UX Evaluation of a Mobile Application Prototype for Art Museum Visitors

Pekka Isomursu*, Minna Virkkula**, Karoliina Niemelä*, Jouni Juntunen*** and Janne Kumpuoja***
*School of Media & Performing Arts
**Business Department
***Information Technology
Oulu University of Applied Sciences,
Oulu, Finland
e-mail: firstname.lastname@oamk.fi

***Abstract* — In this paper, we discuss user experience evaluation of a prototype mobile application for art museum visitors. The application acts as a personal, virtual museum guide that interacts with the physical surroundings using, e.g., image recognition and Augmented Reality (AR). The study included several techniques of early User Interface (UI) design exploration. Our additions to the AttrakDiff method revealed a deeper layer of user insight that otherwise would have gone unnoticed. Based on our study, we have drawn several design implications that we believe are not only usable in further development of our application, but also useful to others. Some of our key findings were that the application should have a supporting role only, subordinate to the actual exhibition, and the role of good, versatile, and up-to-date content is crucial.**

Keywords - user experience; user evaluation methods; case study; user study; interaction with physical objects.

I. INTRODUCTION

The smARTplaces project [1], co-funded by the European Union, aims to revolutionize the way culture and art can be perceived and consumed using digital technology and new forms of cultural mediation. In the project, we have developed a mobile application called smARTapp (Figure 1) where one can learn about the institutions, art works and local projects through, e.g., exclusive videos, Augmented Reality (AR) features, and a game called Storyworld [2].

In this paper, we discuss user evaluation of a new application, to be integrated in smARTapp. We call it Your Personal Art Tour (YPAT). YPAT focuses on enhancing the experience of a visit to an exhibition. Since YPAT is still under development, a lo-fi prototype that worked on a mobile phone and included the basic functionality with a rudimentary user interface (Figure 2) was used in this study.

In the following sections, respectively, we describe related work, YPAT in more detail, and user experience (UX) evaluation setup and procedure. We then discuss the results in detail, and end with conclusions and future work.

II. RELATED WORK

A. User Experience

Traditional usability evaluations mainly focus on user cognition and user performance when interacting with products or services [3]. According to ISO 9241-210:2010 (clause 2.15), UX is defined as a person's perceptions and responses resulting from the use and/or anticipated use of a product, system or service [4]. User experience focuses on lived experience. Therefore, in UX evaluation we need to concentrate on how the experience of a system subjectively feels to the user. It is associated with emotional, experimental, affective, hedonic, and aesthetic variables. Context-dependence is also an important aspect of user experience [5]-[7].

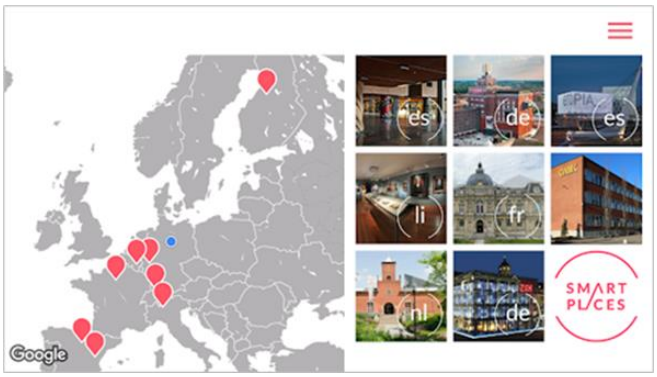

Figure 1. Front page of smARTapp for iOS and Android phones [8].

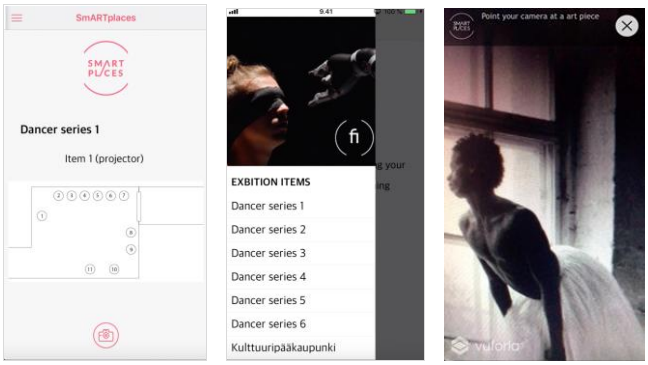

Figure 2. Screen shots of the lo-fi prototype of YPAT, used in user tests.

Hassenzahl [9] has proposed a model of user experience that divides the attributes of a product into pragmatic and hedonic attributes. Based on this model, he has developed two questionnaires, AttrakDiff and AttrakDiff 2 that can be used to measure the user's experience of different attributes in the product. AttrakDiff questionnaires use a seven-step Semantic Differential Scale to assess pragmatic and hedonic attributes as well as the attractiveness of the system under

 ISBN: 978-1-61208-761-0

scrutiny. The attributes are arranged into word-pairs (semantic differentials) that have opposite meanings (e.g., *confusing - clear, good - bad*) [9]-[12].

Pragmatic quality, in this context, means clarity of interaction and usability of the application. Attractivity means aesthetic quality in general. Hedonic quality attributes are divided into two groups: Identity, measuring how well the user's self-perception resonates with the product, and Stimulation, measuring perceived potential of the application for reaching the user's individual goals.

B. Mobile Museum Applications and Their Research

Using mobile technology for enhancing museum experience is not a new idea per se. There are many applications that offer different types of support to enhance the experience during either a physical or a virtual museum visit, or in learning about art world in general. Typically, the art-oriented apps use image recognition technology, each with a particular twist. Some use AR, some even make the whole tour virtual. The applications vary a lot in their focus and technology. Our focus is in making a pleasant user experience for the whole "life cycle" of the museum experience, starting from the planning of the visit and ending with support for activities after the visit [13]-[15].

Applications like Magnus [16] try to become "Shazam of art". Magnus has used, e.g., crowdsourcing to build a database of more than 10 million images of art. It aims to help prospective art buyers. Magnus shows prices from galleries and auctions, and exhibition histories of galleries, museums, etc. Smartify [17] is more geared towards museumgoers. It teams up with individual museums to create digitized versions of their collections, also adding an educational angle.

Ree and Choi [18] have done user research on using mobile technology with museum visitors. The results were somewhat mixed. As the biggest challenge, they identify encouraging visitors to use the mobile experience. Several problems, such as intrusiveness, isolation, head-down effect and technical problems should be improved to use their mobile application. On the other hand, the usability and the degree of satisfaction of using the application were relatively high in their research.

A study by Rung and Laursen [19] shows that there is a growing potential for using mobile applications in museums. However, as this is a new(ish) approach for most museum visitors, mobile applications must be developed as user-friendly as possible and make a strong connection with the physical space.

III. YOUR PERSONAL ART TOUR (YPAT)

Using image recognition and Augmented Reality, YPAT is designed to enhance the experience of visiting art museums. In the physical space, an artwork is recognized with a mobile phone camera, and additional information, such as text, video, audio or web content, is displayed either in some "traditional" format or as Augmented Reality. The information provided can be pre-existing or created specifically for the app. A floor plan and a tour map help in navigation. Overall, YPAT aims to a personalized experience that resembles having a personal, live guide during the visit.

As discussed, mobile applications that enhance the experience of visiting a museum or an art gallery already exist, even commercially. Therefore, it is of crucial importance that YPAT not only has the functionality but also has its user experience at a very high level. Building blocks are readily available for the development of mobile applications that use enhanced technologies, such as image recognition and Augmented Reality. Instead of re-inventing the wheel, with YPAT we use proven technology of commercial development platforms (e.g., React Native [20] and Vuforia [21]) that can easily be adapted to our needs. We can then focus our project resources better to creating a product with excellent user experience and usability.

Image recognition can be done in several different ways, usually either in device or on some external server [22]. Server-side image recognition is better when there are thousands of reference images that need to be compared to a mobile camera image since the processing power of mobile devices is somewhat limited. In the case of YPAT the number of images that need to be recognized is relatively small, so an in-device approach was chosen. The camera image is compared against a point cloud that is stored in the device. If similarity is detected, the application returns a corresponding AR view - or some other pre-defined function - on the phone display.

IV. UX EVALUATION

A. Evaluation Setup

In our research project, our objective was to apply the user centric design process and involve the users to the development of YPAT, our mobile application for art museum visitors. In a user study that we conducted, we focused on the UX evaluation of YPAT. During that time, YPAT had a rudimentary user interface (UI) and the basic functionality working. The aim of the user study was to gain knowledge on people's behavior, interaction and how the users feel when using the developed application prototype in a museum environment. We wanted to find the best combination of features, content and UX.

To create an authentic yet controllable test environment, we created our own "art museum". We used a part of the art collection of our university as the exhibited items. The exhibition included drawings and photographs hung on the walls of a space normally dedicated to exhibit works of our students. We also included images of artworks projected on the wall, in order to see if they would be harder for YPAT to recognize than the physical artworks. The environment, although limited in size, provided all key elements needed to make the tests realistic. We felt that evaluating interaction and user perceptions in a real-world context was crucial for getting valid user feedback.

We recruited in situ 31 participants (14 males and 17 females). They included both students and staff with age range of 20 to 50+ years with bias towards cultural studies and occupations. Typically, they visited museums 2 to 5 times in a year. The age range is quite wide, but we did not

 ISBN: 978-1-61208-761-0

focus on age differences at this early stage, although we do indicate some such differences in the results.

B. Procedure

We conducted the user study with a mixed methods research design combining several methods, e.g., observation, a questionnaire (in 3 parts, including a modified AttrakDiff questionnaire), and semi-structured interview [15].

At the beginning of every user observation, a brief introduction was given about the YPAT application. The first task to the participants was to walk freely at the gallery, using the prototype version of YPAT (Figure 3). Participants used one of the two test phones where the prototype application had been installed. They were followed while they took their time to look at the artworks and test YPAT by themselves. We also asked them to think aloud while using YPAT.

Figure 3. Scenes from user evaluation in progress.

After the participants had tried the application on their own, we would guide them to try features that they had possibly missed. Meanwhile, they were asked additional questions on the concept ideas. If at some point they got stuck with the UI, we first let them try to solve the problem by themselves, but if that did not happen, we would then instruct them. The study also included a semi-structured questionnaire that was filled in after the participants had used YPAT. Finally, a brief interview was run to elaborate on their answers to the questionnaire. In some cases, when there were two people tested at the same time and they knew each other, we let them try the app together as a pair. We noticed that this would spark a lively discussion on the app and its features, both while they were trying YPAT and during the final interview after they had individually filled in the questionnaire.

In the questionnaire, the participants first gave demographic information and their prior experience in visiting art museums. We also asked about their phone model to recognize if there were any correlations between ease of use and the participants' phone UI. The questionnaire also included a modified AttrakDiff questionnaire [15][23] with 15 statements related to application concept idea and a 7-point scale for attribute pairs (Figures 4 and 5).

As YPAT at that stage was only a lo-fi prototype with a rudimentary UI, we felt that the attributes for the hedonic quality used in AttrakDiff were rather meaningless for the participants at that point. It would have been hard for them to grasp, e.g., how *stylish*, *premium*, or *professional* user experience the final YPAT would offer. Therefore, we modified the AttrakDiff questionnaire by omitting the hedonistic attributes and only used attributes for pragmatic quality and appeal.

In addition, as we had to translate the questionnaire to Finnish, we found that the connotative meanings of three attribute pairs in English overlapped with each other when translated to Finnish, i.e., a word in Finnish might have similar connotations to more than one of the English words and vice versa. We ended up using two attribute pairs in Finnish language to cover the key connotative meanings of three pairs in English, namely *pleasant - unpleasant*, *attractive – ugly*, and *likeable - disagreeable*. These were substituted with Finnish *miellyttävä – epämiellyttävä* and *viehättävä – ruma*.

We also added two new attribute pairs, namely *innovative – ordinary*, and *engaging – boring* (in Finnish). We wanted to use these exact words since in the project plan a set goal was to develop an *innovative* application that would *engage* museum audiences in new ways. With the addition, we would get direct feedback on this goal. We consider *engaging – boring* to measure attractivity, and *innovative - ordinary* to measure pragmatic quality, although the latter has a hedonistic dimension as well.

We also wanted to dive a step deeper into the quantitative feedback from AttrakDiff than what the original method allowed. After a participant had filled in the questionnaire s/he was asked to select 3 attribute pairs (Figure 4) that s/he felt most certain about and then justify the selection. This revealed a deeper layer of user insight that otherwise would have gone unnoticed. It helped us better understand the users' reasoning in grading the attributes and what the most relevant and descriptive attributes in this case were.

As YPAT interacts with physical pieces of art in its environment, we found it to be crucial that the application was evaluated in a gallery environment. This gave a lot of insight to issues related to control and performance.

The methods and process that we used worked very well together. Data from direct observations gave us understanding how participants interacted with the lo-fi prototype as well as ideas on what part and features of YPAT the participants were interested in. From the interviews and open-ended questions that followed, we collected valuable insight and ideas for new features. We were able to exploit rather brief (ca. 30 minutes) user sessions to their fullest and gather plenty of versatile and easy-to-analyze user data that we could use in further development of YPAT. We can conclude that our methods mix and the process we followed worked well in real-life early phase development work.

V. UX Evaluation Results

A. Results of subjective ratings with modified AttrakDiff

Summarizing the user answers to our modified AttrakDiff questionnaire, Figure 4 shows that the participants were most certain about the app to be simple, practical, and

manageable (shown in darkest colors in the figure). To a large extent, they thought the app also to be straightforward, pleasant, good, and very motivating. They were least certain whether the app was inviting – rejecting or appealing – repelling. They had most diverse opinions on whether the app was engaging or boring. The diversity with engaging – boring might be due to the fact that the app was still a prototype. When answering, some of the users might have thought of the actual prototype at hand whereas others might have thought of the final product of which the prototype gave just an indication. When asked why the participants chose simple and practical, their reasoning was that they could easily begin to understand the basic functionality and content of the application. Also, the users said that it was easy to take the application into use, as well as interact and learn with it. The reasoning for choosing the attribute motivating was that the application tempted the user to find out more information about the works of art and their background, such as information on the artist and related work.

"Innovative = I haven't seen this before,
Predictable = I quickly learned how it works,
Engaging = I wanted to start exercising right away."

In Figure 5, the darkest color shows the median answer for each attribute, and the lighter color shows the 90% range of the answers. From the figure we can see that overall, the participants felt rather positive about YPAT as the medians are mostly on the left side of the table. A notable exception is that the participants found the app to be more technical than human (although not with high certainty, as can be seen from Figure 4). When asked about this, the users did not necessarily see the app being technical as a negative thing. Since the app used new technology, such as AR, it simply gave a technical impression.

The questionnaire ended with open questions related to first impressions, likes and dislikes, possible new functionality or content and, lastly, a possibility for the participant to add anything at all that s/he still wanted to say. As at this point, they had used the app, discussed it with the moderator, and filled in most of the questionnaire, they had formed a good understanding of what the goals of the app development were. Thus, we got excellent additional comments on the user experience as well as on features that could be added to the app.

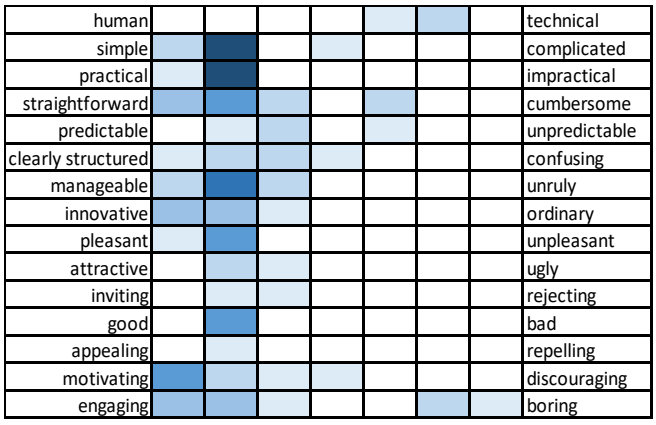

Figure 4. Participants were most certain of the answers marked dark.

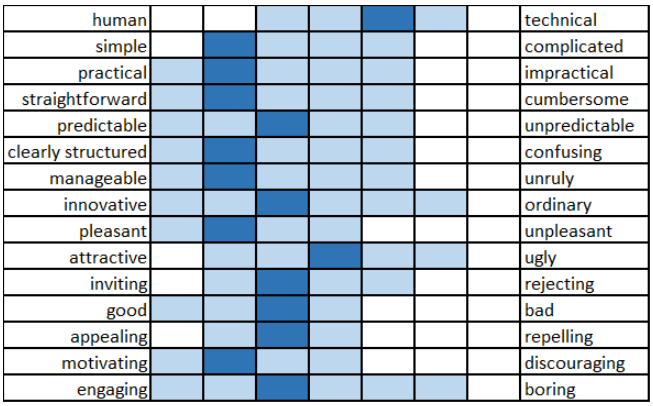

Figure 5. Median (darker) and 90% range (lighter) of the answers.

From the user evaluation of AttrakDiff attribute pairs, we can conclude that, overall, the test users found the app to be rather pragmatic and attractive. This is a very promising indicator for the success of the finalized application. The design implications that we gathered give us a good direction to further development.

B. Design implications

To further develop YPAT, consistent themes and findings from the study were translated into design implications. The implications suggest that the following aspects should be considered when designing a personal digital art guide in the museum context:

- Supporting role of the application: at the exhibition, physical works of art are the focus of attention.
- Varying contexts of use: user journey with the application can start at different points and with different goals.
- Content is king: the role of good content is crucial for the success of the application.
- Considerations on interaction and technology: we found plenty of improvement ideas related to technology and interaction.

Next, we discuss these design implications in more detail.

1) Supporting role of the application

Our first major finding and an important guideline for further design was that at the museum the users want to focus on the art physically around them, and not on their phone application. Also, the users mentioned how important it is that the application gives freedom to choose the objects that they find most interesting and study them at their own pace. Human museum guides are unapproachable to many as people tend to be shy and often wish to study the exhibition in peace, but still wish to get extra information. YPAT gives freedom to choose the objects that the user finds most interesting and focus on them without any hurry.

"Simplicity and practicality are important, because I want to be at the museum, not on my smart phone"

2) Varying contexts of use

The application must take into account different contexts of use. The users not only wanted to use the application

during the museum visit, but also before and after it, with different focus in each context.

Before visiting an exhibition, people wanted to get to know the basics of the exhibition(s) and plan their own tour. For example, users could identify the works of art they would wish to see, and the app could tailor a personal tour accordingly.

"I would plan my own tour", "I would search the object from the (interactive) floor plan"

The use of the application would be most versatile during the visit. For example, an interactive map would show the location and where to go next and give more information about the exhibited works of art, as well as practicalities, such as where the amenities are located. An augmented audio guide would include image recognition with camera and a possibility to bookmark favorites for closer study after the visit.

To store information for later use was considered a useful feature. After the museum visit, the user might wish to learn more about selected favorites – or just simply remember which works of art s/he found especially interesting. People were also interested in having social aspects included in the application. Enabling easy and fun ways for social activity and sharing during and especially after a visit was listed as an important function. Quick social sharing could happen during the visit, but also afterwards. After the visit the user could better afford a longer and deeper social engagement since it would not interfere with the physical experience at the museum. The importance of social sharing emerged especially with the younger (student) participants.

One detailed idea for social sharing that emerged is e-postcards provided by the museum, to be shared via email or social media. Another idea was the possibility to give recommendations to users with similar interests.

Our user evaluation revealed three alternative starting points for the user journey with the application:

1. Start by planning own tour beforehand.
2. Start at the exhibition by scanning a work of art with the phone camera to get information.
3. Start from an interactive map at the exhibition.

Additional entry scenarios exist, such as starting by finding the amenities at the museum, but the above-mentioned three starting points were the ones emerging strongly from the user data. The UI of YPAT should be designed so that access to all three is easy and intuitive.

3) Content is king

Without versatile content, the application, no matter how good its technology and usability will get, is worthless. The users were clearly interested in additional information about the works of art that especially interested them: the subject and characters, the artist's own thoughts, where else can one see works from the same artist, etc.

Our study also showed that the application encourages the user to the consumption of additional information. This is due to making the information readily and interestingly available, reducing the need for the use of web search engines or similar. We found this to be more important to the older study participants.

Content should be hierarchical: one should easily get an overview and then be able to dive into details, according to personal interest. By content, we do not mean just data, but also a variety of functions that provide information to the user. These include interactive map and audio guidance.

Video content that would be consumed during the museum visit should be kept short, a minute at the maximum. This finding is related to the fact that the users wish to focus on the physical world during their visit. When watching videos after the visit this time restriction does not apply.

4) Considerations on interaction and technology

As the app was still a prototype during user evaluation, it is natural that we found a lot of technical details that need improvement. For example, there needs to be indicators when the camera is scanning, when it recognizes an image, and which image seen on the display is recognized. We also found some straight-forward bugs, such as the app sometimes showing information about a wrong image.

Some users tried to find the limits of the implemented technology: what happens when there are several works of art in camera view at the same time, how tilted can the viewing angle be, what if the object is only partially visible, etc. This gave us very valuable information for further development.

In a museum environment, issues with user embarrassment should be considered. Users do not want the application to disturb others. For example, it is good to give the user control of audio usage and volume before showing videos or starting guidance and perhaps force the use of headphones. Also, the user should not be overloaded with unnecessary information, such as push notifications.

As discussed earlier, in a museum the user prefers to focus on art itself and not on her phone. Using audio helps in getting eyes off the device.

Interaction with the physical works of art should be smart and feel natural. The user needs to feel s/he is in control, not the application. Perhaps a bit surprising finding was that the application recognized the works of art even too quickly, already before the user had pointed the phone camera directly towards the object. This caused confusion. Image recognition (or failure of it) must be clearly indicated on the phone display. Using AR to point the identified object on the display would be good. Another issue with the camera was that the users changed the orientation of the phone to better match the dimensions of the artwork with those of the camera display, but our prototype was made to work only with portrait orientation.

Battery consumption of the prototype was quite heavy. It consumed 7-10% of battery capacity during a 15-20-minute test period that included heavy usage of the camera. This needs to be taken into consideration in the coding and procedural structure of the final application.

The light in an art museum is often constant, at least in most of its exhibition space. This makes image recognition much easier than, e.g., outdoors with constantly changing light conditions. Image recognition worked very well in our tests for 2D objects on the walls. However, sculptures and

 ISBN: 978-1-61208-761-0

other 3D objects would be more challenging. We did not include handling of them in YPAT at this point.

VI. Conclusion and Future Work

Our user evaluation confirmed that the YPAT prototype has potential. The feedback was generally positive even though the UI was rudimentary. The users were able to easily learn and interact with the app, and they liked the features we had. However, the visual appearance and elements for interaction need to be improved. We got a lot of ideas for improved and new functionality as well as simple bug fixing.

Whatever the functionality, the application should have a supporting role only, subordinate to the actual exhibition. Besides working on the application itself, a lot of work needs to be done to get good quality (and interactive) content for the application continuously in the future. Since the content would change with every exhibition, tools and instructions should be created that make content creation and putting it into the system as easy as possible. This is especially true with special types of content, such as AR. Also, support for social activity and sharing especially after the visit should be available.

There are especially plenty of opportunities for new functionality with an interactive floor plan. Adding gamification elements to the app is another track that came up in user evaluations and is worth studying closely. Although the prototype did not include a chatbot several test users said it would be an interesting feature. Also, recognition of 3D objects should be addressed in future versions of YPAT. Copyright issues may be a problem in the future since it would be logical for the app to use images of the original works of art.

Acknowledgment

We gratefully acknowledge that smARTplaces is co-funded by the Creative Europe Programme of the European Union [24].

References

[1] smARTplaces Project Web site. Available from: https://smartplaces.eu/ 2020.10.14

[2] smARTplaces Application Web site. Available from: https://smartplaces.eu/explore-the-new-smartplaces-app/ 2020.10.14

[3] ISO/IEC CD 25010.2 standard. International Standardization Organization (ISO). Switzerland

[4] ISO DIS 9241-210:2010. Ergonomics of human system interaction - Part 210: Human-centred design for interactive systems (formerly known as 13407). International Standardization Organization (ISO). Switzerland

[5] E. Law, V. Roto, M. Hassenzahl, A. Vermeeren, and J. Kort, "Understanding, Scoping and Defining User eXperience: A Survey Approach," ACM SIGCHI Conference on Human Factors in Computing Systems (CHI'09), pp. 719-728, 2009.

[6] N. Bevan, "Classifying and Selecting UX and Usability Measures," International Workshop on Meaningful Measures: Valid Useful User Experience Measurement (VUUM), Reykjavik, Iceland pp. 13-18. E. L-C. Law, N. Bevan, G. Christou, M. Springett, and M. Lárusdóttir, Eds. 2008.

[7] J. Isleifsdottir and M. Larusdottir, "Measuring the User Experience of a Task Oriented Software," International Workshop on Meaningful Measures: Valid Useful User Experience Measurement (VUUM), Reykjavik, Iceland pp. 97-102. E. L-C. Law, N. Bevan, G. Christou, M. Springett, and M. Lárusdóttir, Eds. IRIT, 2008.

[8] smARTplaces Application at Google Play Store. Available from: https://play.google.com/store/apps/details?id=de.menschortweb.smartplaces 2020.10.14

[9] M. Hassenzahl, M. Burmester, and F. Koller, "AttrakDiff: Ein Fragebogen zur Messung wahrgenommener hedonischer und pragmatischer Qualität," In J. Ziegler & G. Szwillus, Eds. Mensch & Computer. Interaktion in Bewegung, pp. 187-196, Stuttgart, Leipzig: B.G. Teubner, 2003.

[10] A. Colley, M. Pakanen, S. Koskinen, K. Mikkonen, and J. Häkkilä, "Smart Handbag as a Wearable Public Display - Exploring Concepts and User Perceptions," AH 2016, February 25-27, 2016, Geneva, Switzerland, pp. 1-8, ACM. ISBN 978-1-4503-3680-2/16/02

[11] H. Väätäjä, T. Koponen, and V. Roto, "Developing Practical Tools for User Experience Evaluation – A Case from Mobile News Journalism," ECCE 2009, Helsinki, Finland, pp. 1-8, ACM, 2009.

[12] M. Hassenzahl, "The thing and I: Understanding the relationship between users and product," In Funology: From usability to enjoyment, M.A. Blythe, K. Overbeeke, A.F. Monk, P.C. Wright, Eds. Kluwer, The Netherlands, pp. 31-42, 2003.

[13] C. Coates, "How Museums are using Augmented Reality," MuseumNext. Available from: https://www.museumnext.com/article/how-museums-are-using-augmented-reality/ 2020.10.14

[14] C. Shin et al., "Unified Context-Aware Augmented Reality Application Framework for User-Driven Tour Guides," Int. Symposium on Ubiquitous Virtual Reality, pp. 52-55, IEEE. 2010.

[15] P. Isomursu, M. Virkkula, K. Niemelä, J. Juntunen, and J. Kumpuoja, "Modified AttrakDiff in UX Evaluation of a Mobile Prototype," Int. Conference on Advanced Visual Interfaces (AVI '20), pp. 1-3, ACM ISBN 978-1-4503-7535-1

[16] Magnus Application Web site. Available from: http://www.magnus.net/ 2020.10.14

[17] Smartify Application Web site. Available from: https://smartify.org/ 2020.10.14

[18] B. Rhee and Y. Choi, "Using Mobile Technology for Enhancing Museum Experience: Case Studies of Museum Mobile Applications in S. Korea," Int. Journal of Multimedia and Ubiquitous Engineering vol. 10, no. 6, (2015), pp. 39-44 http://dx.doi.org/10.14257/ijmue.2015.10.6.05

[19] M. H. Rung and D. Laursen, "Adding to the Experience: Use of Smartphone Applications by Museum Visitors," The Transformative Museum Conference, Roskilde University, Roskilde, Denmark, ed. / Erik Kristiansen, pp. 314-324, 2012.

[20] GitHub Web site for React Native. Available from: https://github.com/facebook/react-native 2020.10.14

[21] Vuforia development Web site. Available from: https://developer.vuforia.com/

[22] T. Guo, "Cloud-based or On-device: An Empirical Study of Mobile Deep Inference," IEEE International Conference on Cloud Engineering (IC2E), pp. 184-190, 2018.

[23] Attrakdiff Web site. Available from: http://www.attrakdiff.de/ (ver. 10.12.2019). 2020.10.14

[24] Home page of Creative Europe Programme of the European Union. Available from: https://ec.europa.eu/programmes/creative-europe/ 2020.10.14

 ISBN: 978-1-61208-761-0