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USER EXPERIENCE EVALUATION AND CREATIVITY STIMULATION WITH AUGMENTED REALITY MOBILE APPLICATIONS

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Abstract. While customer information and knowledge need transform in the context of globalization and technological change, it is important for organizations to efficiently meet new and changing needs and stimulate consumer creativity through the use of augmented reality mobile applications. In order to solve this kind of problem, it is important to evaluate mobile applications with respect to user experience. The purpose of this study is to evaluate alternative research methods for user experience assessment in augmented reality, to determine whether the selected user experience survey method is suitable for augmented reality mobile applications' evaluation, and to identify features, which would improve augmented reality mobile applications in order to enhance users' creativity and positive attitude. The article presents the analysis of theoretical aspects of evaluation of augmented reality mobile applications, the concept of the augmented reality, the augmented reality mobile application evaluation results and the recommendations for the user's creativity stimulation. Research methods such as scientific literature analysis and user experience survey are used to achieve the purpose of the article.

Keywords: augmented reality, customer creativity stimulation, mobile application, user experience assessment.

Introduction

Society transformation from the information society into the knowledge society is changing the conditions of the external environment, the information and knowledge needs of customers, which causes changes in the organizations' communication with the target customers (Davidaviciene, Pabedinskaite, & Davidavicius, 2017; Raudeliūnienė, Davidavičienė, Tvaronavičienė, & Jonuška, 2018) while creating augmented reality (AR) mobile applications (MAs) to meet user's creativity needs.

In the context of transformations, satisfaction and stimulation of consumer information and creativity needs through AR MAs is an effective mean of increasing the efficiency of public administration institutions and business organizations in marketing communication

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with target customers (Rashid, Mohamed, & Hussin, 2018; Raudeliūnienė et al., 2018). An organization's communication with target customers is becoming an important aspect: how at minimal costs to create and apply AR technologies to consumers for to not only meet their needs of information and knowledge, but also to promote their creativity and loyalty to the organization (U. Akram, Hui, Khan, Yan, & Z. Akram, 2018; Cachero-Martínez & Vázquez-Castielles, 2017; H. Akrout, Diallo, W. Akrout, & Chandon, 2016).

AR is defined as a technology that combines the real-world environment with the virtual one supplementing it with digitally programmed information that is decoded using a dedicated device with recorded software – such as a smartphone, tablet, smart glasses, *etc.* (Carmigniani et al., 2011; Berryman, 2012; Kipper & Rampolla, 2012; Chi, Kang, & Wang, 2013; Cianciarulo, 2015; Capuano, Gaeta, Guarino, Miranda, & Tomasiello, 2016; Javornik, 2016; Laine & Suk, 2016; Mota, Ruiz-Rube, Dodero, & Arnedillo-Sánchez, 2018). Popularity of AR technology is driven by technological development – devices that can be used for AR have improved significantly, became cheaper and accessible to a wider public, and programs have been developed in a way that is user-friendly and intuitive (Dey, Billinghurst, Lindeman, & Swan, 2016; Javornik, 2016; Nam, 2015; Rese, Baier, Geyer-Schulz, & Schreiber, 2017). Researchers predict that by 2020 the market value of the AR is expected to reach about 56.8 billion USD (Javornik, 2016) and will have about 1 billion users (Liao, 2016). It is also noticed that over the past decade there has been an increase in usability studies in the field of AR, especially related to mobile devices (Dey et al., 2016), as one of the most commonly used types of AR is the mobile AR whose content is decoded by smartphone or tablet. These devices (high-quality graphics, camera, sensors) provide the prerequisites for creating a successful AR experience (Dey et al., 2016; Georgiou & Kyza, 2017), so more and more AR MAs emerge recently (Laine & Suk, 2016; Rauschnabel, Rossmann, & Dieck, 2017) that are easily accessible to the general public.

With the increasing number of cases of application of the AR, there is a need to analyze the user experience (UE) (Dey et al., 2016; User Experience Questionnaire, 2018; Schrepp, Hinderks, & Thomaschewski, 2014, 2017) and stimulation of user's creativity both developed by this technology and related to user loyalty. Therefore, the purpose of this article is to evaluate alternative research methods for UE assessment in AR, to determine whether the selected UE survey method is suitable for AR MAs' evaluation, and to identify features, which would improve AR MAs in order to enhance users' creativity and positive attitude.

In this exploratory study, two mobile entertainment-type applications of AR enhancing user's creativity were evaluated: *Quiver Application* (*QA*, an application that helps to playfully revive the special colored drawings with the help of AR) and *INKHUNTER* (an application of AR that helps to test virtual tattoos directly on your body) in order to test the alternative research method. These applications are chosen because they do not require long-term user engagement, are simple to use and reflect the essence of the AR. In order to assess the mobile AR applications in terms of consumer experience and creativity need satisfaction, research methodologies such as scientific literature analysis and UE survey have been employed. The latter method provides preconditions for UE to be analyzed using multidisciplinary approach through the oppositional scales of object attributes according to factors such as attractiveness, comprehensibility, efficiency, addiction, stimulation and innovation (Santoso, Schrepp, Isal, Utomo, Priyogi, 2016; Schrepp et al., 2014, 2017; Ch.-H. Wang; Chiang, & M.-J. Wang, 2015).

1. Literature review

AR technology started to become popular only in the last decade, although the first time it was used on military aircrafts (information about enemy targets' coordinates, *etc.*). Subsequently, head-mounted devices were created, which helped to integrate computerized information into reality. For the first time, the term "AR" was used back in 1990 by Thomas P. Caudell and David W. Mizell working for *Boeing* (Berryman, 2012; Milgram, Takemura, Utsumi, & Kishino, 1994). In 1997 Ronald Azuma offers this definition of technology, which is considered classical (Berryman, 2012; Liao, 2016), but with additions to this technology and the increasing use, scientists have expanded the concept of AR by integrating various characteristics of the phenomenon and directions of its development (Table 1).

Gregory Kipper and Joseph Rampolla (2012) define the concept of AR as a technology, field of research, vision of a future computing, growing commercial industry, new media for creative expression. According to Ana Javornik (2016), the most relevant media characteristics that are emphasized in the context of the AR are interactivity, virtuality, geolocational properties, mobility (possibility to carry conveniently), virtual and physical environment synchronization, which is called augmentation. José Miguel Mota et al. (2018) state that the

Table 1. Augmented reality concept (source: created by the authors)

Author(s), year	Definition
Azuma, 1997	Technology that allows the user to see the real environment, supplemented by virtual objects, usually in 3D.
Carmigniani et al., 2011	It is a real-time, direct or indirect view of the physical real-world environment that was supplemented and enhanced by adding virtual, computer-generated information on it.
Berryman, 2012	Technology that covers objects and places in the real world with digital information to enhance user experience.
Kipper and Rampolla, 2012	Technology that complements the real-world environment with digital and computer-generated information, including photos, pictures, audio and video materials.
Chi et al., 2013	Augmented reality creates an environment where information generated by a computer is embedded into a user's real-world view.
Cianciarulo, 2015	It is coating of layers with different information (video, graphics, 2D, 3D, audio) on the real environment.
Capuano et al., 2016	The augmented reality complements real-world elements with computer-generated enhancements such as sound, image, animation, and more.
Javornik, 2016	Interactive technology that modifies physical environment by integrating virtual elements. This virtual layer existing between the physical environment and the user can add text information, pictures, videos, or other virtual elements to the user's physical environment view.
Laine and Suk, 2016	The user interface technology, in which the real-world view recorded by a webcam is complemented by computer-generated content, such as text, graphics, animations and 3D models.
Mota et al., 2018	The augmented reality technology refers to the insertion of virtual elements into a real physical world environment view in order to create real-time mixed realities.

concept of AR integrates the perception of the user's environment and improves interaction with the real world by displaying information that the user cannot detect directly using his/her senses.

Based on scientific literature review AR concept can be described as technology that allows the user to see the real environment (Azuma, 1997; Carmigniani et al., 2011; Berryman, 2012; Kipper & Rampolla, 2012), covers objects and places in the real world with digital information (Berryman, 2012), creates an environment where information generated by a computer is embedded into a user's real-world view (Chi et al., 2013) in order to create real-time mixed realities (Mota et al., 2018), to enhance UE (Berryman, 2012) and stimulate creativity.

AR technology is based on the operation of complex technological processes. According to Julie Carmigniani, Borko Furht, Marco Anisetti, Paolo Ceravolo, Ernesto Damiani and Misa Ivkovic (2011), the main principle of operation of this technology is that after the AR technology device identifies and reads (tracks) the information, it renders a virtual computer-generated object from the same viewing point from which the camera has scanned. This object-tracking and virtual video-rendering are key processes that describe the operation of the technology.

According to Kipper and Rampolla (2012) the operation of AR technology is based on the interaction of the following key components: hardware (computer or smart device; monitor, display; camera; tracking and sensor systems; network infrastructure (Internet access); marker (physical object or place after scanning of which the device decodes the augmented information, that is, the location that the technical device identifies and provides encrypted digital information) and software (MA or computer program; Internet services; content server).

The researchers (Billinghurst, Clark, & Lee, 2015; Mota et al., 2018) distinguish the following main methods of tracking of AR: marker-based tracking and markerless object tracking. One of the main components of the AR technology is a technological device for decoding the augmented information. According to Kipper and Rampolla (2012), most commonly for AR technology the following devices are used: personal computers with integrated camera (webcam); digital stands, screens, projectors (virtual, magic mirror); smartphones and tablets; AR glasses (*Google* Glass, *Microsoft* HoloLens).

The researchers (Dey et al., 2016; Georgiou & Kyza, 2017) state that smartphones are one of the most popular devices for the use of AR technology. AR, for which mobile devices are used, is called mobile AR and is defined as technology that extends the physical world with virtual objects and information through mobile devices (Nam, 2015). Most of the major global organizations (such as *Coca-Cola*, *McDonald's*, *General Electric* and others) have incorporated AR technology into their marketing programs (Scholz & Smith, 2016) to meet the changing needs of consumers and promote creativity.

More than 200 active mobile AR applications have been registered recently (*Introducing the AR Landscape*, *Google Play*). The major areas of AR applications are content creation (*Aurasma*, *Augment*), games (*Pokémon GO*, *Ingress*, *Silent Streets*), AR browsers (*Blippar*, *Arilyn*, *Layar*), commercial (*IKEA Catalogue*) and social function with augment reality (*Facebook*, *Instagram*, *Snapchat*), entertainment (*INKHUNTER*, *QuiverVision Limited*, *WallaMe*, *Holo*), navigational (*Augmented Reality Navigation*), educational (*Augmented Reality*

Landscape, *Anatomy 4d*) and more functions. The abundance of these application areas shows that AR can be used for different purposes. One of the main goals is meeting the changing consumer needs of information, knowledge and creativity.

Scientists (Billinghurst et al., 2015; Dey et al., 2016) state, that the solutions of the AR are varied and diverse, and therefore there is a lack of versatile and universally recognized research methodologies, although the number of research of the consumer experience in this area has increased over the past decade (Dey et al., 2016). Customer experience can be described as subjective customer feelings about the product (service) used (Santoso et al., 2016). The experience of the end customer is often explored by the researchers (Georgiou & Kyza, 2017; Ko, Chang, & Ji, 2013; Laine & Suk, 2016; Abd Majid, Mohammed, & Sulaiman, 2015; Mota et al., 2018; Rauschnabel et al., 2017) by applying a survey method where evaluated aspects and claims are measured using scales, a combination of closed and open questions is applied in order to find out the motives of the customer (Diaz, Hincapié, & Moreno, 2015; Georgiou & Kyza, 2017; Laine & Suk, 2016; Abd Majid et al., 2015; Mota et al., 2018; Rauschnabel et al., 2017).

Researches, which focus more on qualitative and complex aspects of assessment of the research subject, are based on expert judgment (Paiva Guimarães & Farinazzo Martins, 2014; Ko et al., 2013), consumer focus groups (Georgiou & Kyza, 2017), semi-structured interviews (Liao & Humphreys, 2015).

In evaluating UE, researchers use the following key evaluation tools as system usability scale (SUS), usefulness, satisfaction, and ease of use, usage questionnaire according to International Organization for Standardization (ISO) (usability, effectiveness, efficiency), technology acceptance model (TAM), user experience questionnaire (UEQ).

SUS is a system of statement-based surveys with a 5-point scale, when the user, after the use of the system, is asked 10 questions analyzing the main processes of product use – ease of use, fluidity, comprehensibility, satisfaction (Albertazzi, Okimoto, & Gitirana Gomes Ferreira, 2012).

Usefulness, satisfaction, and ease of use (USE) questionnaire is based on criteria with 7 levels and consists of 30 questions that analyze the product in key dimensions such as usefulness, ease of use, ease of learning, and satisfaction. Two open questions are also asked where the user is requested to identify the main negative and positive aspects of the subject being evaluated (Albertazzi et al., 2012).

Usage questionnaire according to ISO is based on the criteria by assessing the systems of AR. The researchers (Paiva Guimarães & Farinazzo Martins, 2014) proposed a method for assessing applications of AR based on the definition of usability in ISO-09241-11 standard, which distinguishes key factors such as effectiveness, efficiency and satisfaction. In order to evaluate these factors, researchers have provided a control question list for the evaluation of applications of AR (Paiva Guimarães & Farinazzo Martins, 2014).

TAM focuses on user responses to new technology and on how do they accept it. With the help of the questionnaire in classical model the evaluation is performed in accordance to 3 dimensions – usefulness, ease of use, intention to use (Mota et al., 2018). Adapting this model to the context of the AR integrated are such evaluated aspects as satisfaction, informativeness, approach to use (Rese et al., 2017), interactivity, enjoyment, quality of information, response time, aesthetic features, and more (Pantano et al., 2017).

UEQ was prepared from the opposition scales of the object features, evaluating the experience of the end user in terms of attractiveness, comprehensibility, efficiency, reliability, stimulation and novelty (User Experience Questionnaire, 2018; Schrepp et al., 2014, 2017; Wang et al., 2015). The essence of this method is a questionnaire consisting of 26 opposition scales of assessment of features of the object according to 6 dimensions (User Experience Questionnaire, 2018; Santoso et al., 2016; Schrepp et al., 2014, 2017): attractiveness (general impression of the user about the object of assessment); efficiency (whether it is possible to use the product quickly and efficiently, whether the user interface looks organized); comprehensibility (whether it is simple understanding of how to use the product); reliability (whether the user feels that he controls interaction, whether the interaction with the product is safe and predictable); stimulation (whether the use of the product is interesting and exciting, whether the user feels motivated to continue to use the product); innovation (whether design of the product is innovative and creative, whether product attracts user's attention). The researchers (Santoso et al., 2016; Wang et al., 2015) state that the dimensions of effectiveness, comprehensibility and reliability reflect pragmatic features of the object, which are related to achieving the goal, the practical value of the product. The dimensions of stimulation and innovation are attributed to hedonic characteristics that are not related to the attainment of the goal but reflect the pleasure that is brought. The attractiveness dimension reflects the general user's perception of the product and influences the pragmatic and hedonic features of the evaluation object. This assessment method is distinguished by the fact that it provides preconditions for the complex evaluation, therefore, it was decided to check relevance of this method for the assessment of AR MA applications.

2. Research methodology

For testing UEQ two AR MA were choosed – *QA* and *INKHUNTER*. *QA* is an entertaining AR application that brings color-coded special drawings into 3D models that you can play with. *INKHUNTER* is an entertaining AR application where users can try various virtual tattoo designs directly on their body. Photos can be saved, edited and shared with friends on social networks. These two applications were chosen because both of them reflects the essence of the technology of AR. They are popular among young users (more than 1 million downloads in the *Google Play* store), it takes 10–15 minutes for the consumer to know them (to know the purpose and function of the application) (Table 2).

It was decided to treat the users as an expert for this exploratory study, so 6 target users (average age 24, including 3 males and 3 females) who had experience in using these applications were selected. A small sample of respondents was chosen to check whether the

Table 2. *Quiver Application* and *INKHUNTER* application summary (source: created by the authors)

App	The range of downloads	*Google Play* reviews	Average rating on *Google Play*
Quiver Application	1000000-500000	13377	4.0
INKHUNTER	1000000-500000	18467	4.7

user UEQ method is appropriate (User Experience Questionnaire, 2018; Schrepp et al., 2014, 2017) for assessing the AR MAs. This decision is based on J. Nielsen (2000) suggested attitude to usability test sample. During the study, users were asked to perform certain tasks (using *QA* – to paint a few drawings and to test application functions; using *INKHUNTER* – to test several virtual tattoo designs, take pictures, share them on the social network) to encourage them to become more familiar with the applications. Because the device used for applications can also affect the UE, the users involved in the study were given one device – the LG G3 smartphone in the *Android* (operating system) environment. This device features high-performance camera (13Mbs), high image quality (4K), large display (5.5") and special sensors for the smooth operation of AR. The evaluation results in opposition feature scales of the UEQ method are converted into numerical values from –3 to +3, where –3 denotes the most negative value, 0 – neutral, and +3 denotes the most positive value. On a scale whose values are more than +1 identifies a positive estimate, less than –1 – a negative estimate (Santoso et al., 2016). In order to interpret the assessment of the UE of the product being evaluated, the researchers propose to compare results with the proposed benchmark in the UEQ method, which is based on the 246 other product evaluation data (Santoso et al., 2016).

3. Research results and discussion

After the exploratory study, evaluation of each AR MA by 6 dimensions (attractiveness, efficiency, comprehensibility, reliability, stimulation and innovation) was obtained. The *QA* evaluation results (Figure 1) showed that the overall assessment of the UE with *QA* is positive – in all dimensions analyzed the value obtained exceeds 0.8.

By users, the best in *QA* is considered to be innovation (2.583) and attractiveness (2.611). This shows that the application with its content is extremely attractive and innovative to its users. It can be assumed that the innovation in this application is, most of all, created by the AR technology. The factors that received the lowest scores were reliability (1.458) and com-

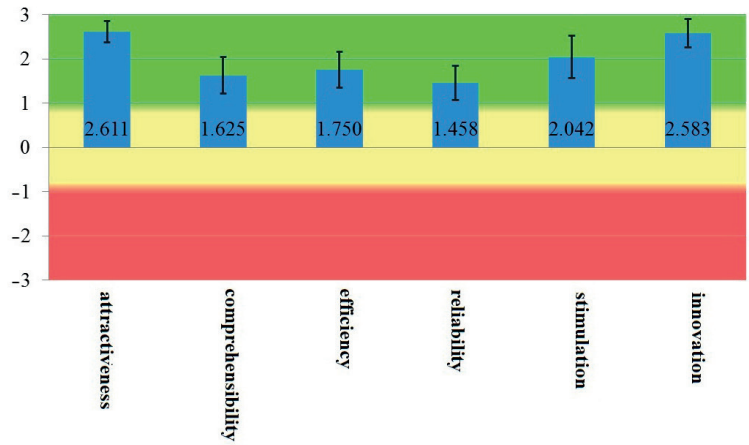

Figure 1. *Quiver Application* evaluation results using user experience questionnaire method (source: created by the authors)

prehensibility (1.625). In order to grasp the problem areas encountered in these dimensions, separate assessments of their scales were reviewed:

- reliability (unpredictable/predictable (–0.7); interfering/helping (1.8); insecure/secure (2.8); satisfying expectations/not satisfying expectations (1.8));
- comprehensibility (incomprehensible/comprehensible (1.7); easy to learn/difficult to learn (1.8); complicated/simple (0.8); confusing/clear (2.2)).

In reliability group there is a clear distinction with a low estimate in the unpredictable/predictable scale. Other dimension scales received high ratings, which makes it possible to assume that the scale incorrectly measures the meanings of the object. According to the method analysis tool, the feature "unpredictable" is evaluated as negative and the value "predictable" – as positive. In the context of this application, such an assessment is likely to be incorrect as the user perceives that "unpredictable" can mean surprising, creating unexpectedness. For this reason, a problematic area identified by this scale will be considered as a flaw of the applied method. In the dimension comprehensibility, complicated/simple scale received the average rating. There, separation is much smaller from other elements of dimension, so the result is seen as a problematic area. For the user, this application seemed complicated due to the use of new technology and the creation of complex virtual objects – 3D models, due to lack of clarity on how to use this application. Also, when analyzing the evaluations of individual scales, a lower value was observed on the fast/slow scale (1.0), which indicates that, according to users, the application is slow, its use is not completely smooth.

By analyzing the results of the *QA* evaluation according to the structure of the UEQ model (Figure 2), it was observed that in the opinion of the users this application is very attractive (2.61) and having hedonic properties (2.31), the pragmatic features of the application received a lower estimation (1.61). This shows that this application is not very practical but is attractive to the user and more dedicated to pleasure. This result shows that the *QA* is of entertainment type. Examining the results of the *QA* evaluation in accordance with the benchmark standard proposed by the UEQ method (Santoso et al., 2016), *QA* can be regarded as very good, as the assessment of 4 dimensions falls into the range of "excellent"

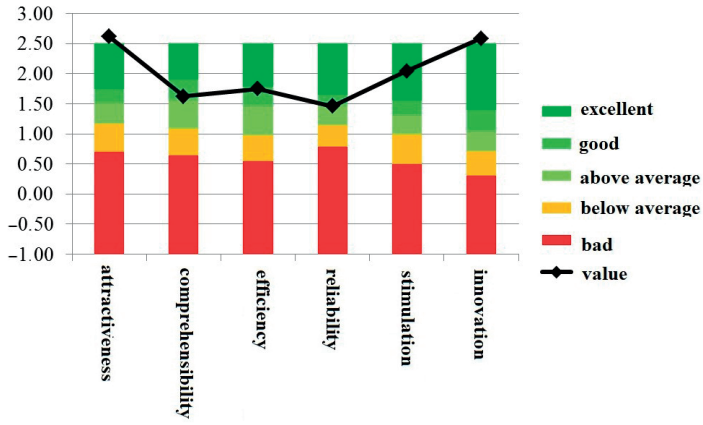

Figure 2. *Quiver Application* evaluation results comparison with user experience questionnaire standard (source: created by the authors)

(attractiveness, efficiency, stimulation, innovation), while the rest of the dimensions falls into the range "good" (comprehensibility, reliability) (User Experience Questionnaire, 2018; Schrepp et al., 2014, 2017).

The results of the *INKHUNTER* application evaluation showed that the overall evaluation of *INKHUNTER* application in terms of UE is positive – the value obtained in all dimensions analyzed exceeds 0.8 (Figure 3).

The best valued dimensions according to the users of *INKHUNTER* application is comprehensibility (2.458) and attractiveness (1.750). This shows that the application is well-understood by the users, is clear, simple, and of easy structure, as well as attractive with its content. Reliability (1.083) and stimulation (1.375) dimensions received the lowest score. In order to understand the problem areas encountered in these dimensions, separate assessments of the scales forming them were reviewed: reliability (unpredictable/predictable (0.3); interfering/helping (1.3); insecure/secure (2.0); satisfying expectations/not satisfying expectations (0.7); stimulation (useful/useless (1.0); boring/exciting (1.2); uninteresting/interesting (1.5); motivating/demotivating (1.8)). As with the *QA* evaluation, a clear exclusion with a low estimate is visible on an unpredictable/predictable scale, so it is assumed that this scale identifies the problem of the research method. In this dimension, another scale has been observed with an average rating – satisfying expectations/not satisfying expectations. This shows that users expect more from the application *INKHUNTER*, the application for the users seems to be too simple and not very valuable in terms of content. Analyzing the results of the *INKHUNTER* application evaluation according to the structure of the UEQ model, it was observed that in the opinion of users, this application is quite attractive (1.75) and having pragmatic properties (1.75), hedonic qualities of the application received the lower rates (1.44). This shows that this application is considered more practical, helping to achieve the goal, but has lower hedonic properties. Analyzing the results of *INKHUNTER* application evaluation according to the standard provided by the UEQ method (Santoso et al., 2016), the *INKHUNTER* application can be considered as good because the assessment of 3 dimen-

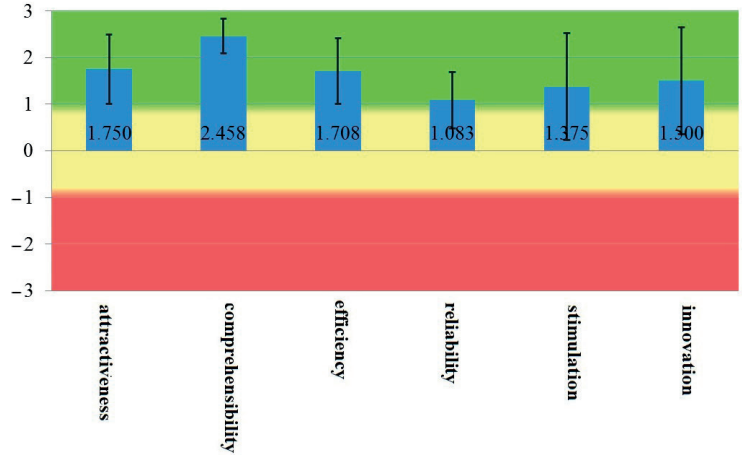

Figure 3. *INKHUNTER* evaluation results using user experience questionnaire method (source: created by the authors)

sions falls into the range "excellent" (attractiveness, comprehensibility, innovation), and of 2 dimensions – into the range "good" (efficiency, stimulation), and one (reliability) is below average (Figure 4).

Comparing the results of *QA* and *INKHUNTER* application evaluation, it has been observed that in almost all dimensions (except for comprehensibility), the *QA* has received a better UE evaluation and thus provides a better UE. In the dimension of comprehensibility, there is a significant difference between the evaluated applications and this shows that the application *INKHUNTER* is much more comprehensible, clearer and simpler.

Summarizing the results of the study, the following problem areas have been identified: *QA* is identified as rather complicated and slow, and the *INKHUNTER* application – as on average satisfying user expectations and creating average value for the user.

Suggestions for improving *QA* and *INKHUNTER* applications in terms of user creativity stimulation according to the problem areas identified in the study are presented in Table 3.

Although UEQ research method evaluates UEs from a multi-dimensional point of view, it has been observed during the study that one of the assessment scales (unpredictable/predictable) is distinguished from the general group by its result. The authors of the method note that if such an assessment scale occurs, this may indicate that its assessment is not correct for possible reasons (Santoso et al., 2016): respondents incorrectly interpret scale values; the scale because of the context of the subject of the study misinterprets the positive and negative aspects of the assessment. It is assumed that this scale, due to the context of the object of the study, incorrectly interpreted the positive and negative values of evaluated applications – unpredictability can be regarded as a positive feature in the context of AR applications, as it creates an unexpected, surprising factor for the user. Also, after the study and in order to identify the problem areas of the assessed objects, there was a shortage of wider qualitative information from respondents, which would help to identify the causes of identified problems. Although the UEQ method provides a comprehensive assessment of the subject under 6 dimensions, there is a lack of data to help understand the causes of the identified problems.

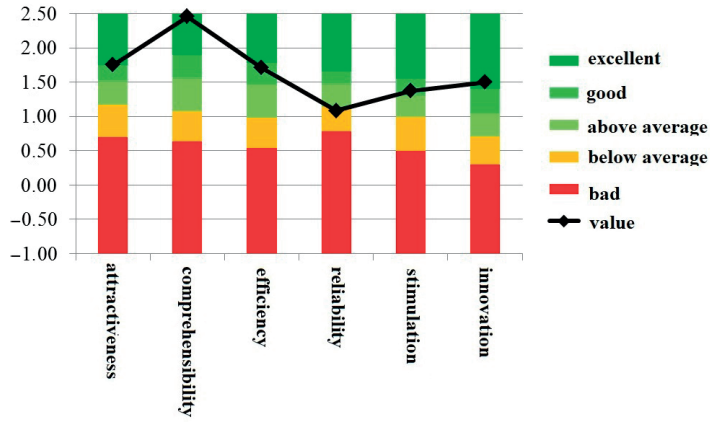

Figure 4. *INKHUNTER* evaluation results comparison with user experience questionnaire standard (source: created by the authors)

Table 3. Recommendations for improving *Quiver Application* and *INKHUNTER* application (source: created by the authors)

Problem areas	Recommendations
Quiver Application: users identify the application as complicated (comprehensibility)	– To improve the clarity of the information provided by adding additional explanations (text or video), reminding the key factors (good lighting, drawing fitting in the screen) before each interaction, a section of frequently asked questions. – To carry out a detailed analysis to determine which application elements are complex, less comprehensible to the target group and eliminate or simplify them.
INKHUNTER application: satisfying expectations on average (reliability)	– To carry out targeted user qualitative studies (focus groups, qualitative interviews) in order to identify what user information and creativity expectations are and how to properly meet them with the help of the application. – To improve the technical aspects of the application (object recognition, virtual image stability) and functionality (the ability to change tattoo colors, the possibility to put your own tattoo design).
Quiver Application: users identify the application as slow (efficiency) *INKHUNTER* application: average usefulness (stimulation)	– Using technical operational testing to measure the timeliness of application usage, identify problem areas (software and hardware problems) and solve them by using programming specialists, providing recommendations for choosing the optimal (sufficiently powerful) device for the user. – To simplify application processes by optimizing them (reducing the size of 3D objects, simplifying functions).

In order to facilitate the use of this method to the AR application evaluation, it is recommended to evaluate the positive and negative values of all scales in the context of the object of the study prior to using the method, that is, whether the values determined by the method correspond to the logic of the object evaluation values, if not – to adjust the data analysis instrument. Also, in order to objectively evaluate the positive and negative values of the scales of the object under study, it is suggested to use the expert assessment method (experts evaluate the relevance of the positive and negative values in the context of the object of the study). In order to find out the reasons and to suggest alternatives to problem areas, it is recommended to apply additionally research methods such as focus groups, in-depth interviews or additional open questions.

Conclusions

Mobile AR is a technology that extends the physical world with virtual objects and information through mobile devices. The popularity of mobile AR is driven by technical AR and mobile device factors – the AR technology itself is already mature enough to be used on the market and its devices are powerful enough to create a smooth AR experience. Mobile AR is increasingly being used in the market for cognitive, creativity, commercial purposes. In order to adapt mobile AR technology to the end-user, UE studies are increasingly being carried out. For such UE assessments surveys often are used with various evaluation tools such as SUS, USE, usage questionnaire according to ISO, TAM, UEQ, which help to assess the developed experience of mobile AR user in a range of dimensions.

This study evaluated mobile AR applications *QA* and *INKHUNTER* with respect to UE. The exploratory study of the UEQ (User Experience Questionnaire, 2018; Schrepp et al., 2014, 2017) method for assessing UE in terms of dimensions such as attractiveness, comprehensibility, efficiency, reliability, stimulation and innovation revealed that it is proper method for such qualitative evaluation. In order to have quantitative results and validate it statistically sample size should be calculated accordingly.

In this research user surveys have shown that the *QA* creates a better UE. A significant difference is observed in the dimension of comprehensibility where *INKHUNTER* is considered to be a more comprehensible application. The study identified the following problem areas of applications: with *QA* – comprehensibility, efficiency, and with *INKHUNTER* – reliability, stimulation. The shortcomings of application of UEQ method has also been identified: the mismatch of the assessment scale according to the context of the subject of the study, the lack of data to determine the causes of the problems.

In order to improve the *QA* UE and encourage user creativity, the following recommendations are presented:

- To make the application more understandable for the user – to investigate which application elements are complex, less comprehensible to the target user group and to remove or simplify them.
- To make the application faster, use technical testing and measure the timeliness of application usage, identify problem areas and solve them by means of programming specialists with recommendations for choosing the optimum (sufficient power) device for the user.

Recommendations for *INKHUNTER*:

- In order to increase the usefulness of the application to the user, it is recommended to cooperate with the tattoo salons and use this application as their commercial tool to stimulate the creativity of the user, to meet the information needs (helps to find new clients), increase sales (discounts, coupons).

To improve the UEQ research method, it is suggested to evaluate the positive and negative values of the scale in the light of the context of the subject of the study and to specify it by means of an expert evaluation and also, in order to propose solutions to problem areas, additionally use methods that create the preconditions for identifying the causes and detailing them.

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VARTOTOJO PATIRTIES VERTINIMAS IR KŪRYBIŠKUMO SKATINIMAS PAPILDYTOSIOS REALYBĖS MOBILIOSIOMIS PROGRAMOMIS

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Santrauka

Globalizacijos ir technologijų pokyčių kontekste kintant vartotojų informaciniams ir žinių poreikiams, organizacijoms svarbu efektyviai tenkinti naujus besikeičiančius poreikius ir skatinti vartotojų kūrybiškumą naudojant papildytosios realybės mobiliąsias programas. Siekiant išspręsti tokio pobūdžio problematiką, svarbu įvertinti papildytosios realybės mobiliąsias programas vartotojo patirties atžvilgiu. Šiuo tyrimu siekiama įvertinti alternatyvius vartotojo patirties tyrimo metodus papildytojoje realybėje, taip pat nustatyti, ar pasirinkti vartotojų patirties tyrimo metodai yra tinkami papildytosios realybės mobiliosioms programoms vertinti ir identifikuoti charakteristikas, kurios pagerintų papildytosios realybės mobiliąsias programas, siekiant padidinti vartotojų kūrybiškumą. Straipsnyje pateikiama papildytosios realybės mobiliųjų aplikacijų vertinimo teorinių aspektų analizė, papildytosios realybės koncepcija, pristatomi papildytosios realybės mobiliųjų aplikacijų vertinimo rezultatai ir vartotojo kūrybiškumo skatinimo rekomendacijos. Straipsnio tikslui pasiekti taikyti tokie tyrimo metodai, kaip mokslinės literatūros analizė ir vartotojo patirties tyrimas.

Reikšminiai žodžiai: papildytoji realybė, vartotojo kūrybiškumo skatinimas, mobilioji programa, vartotojo patirties vertinimas.