

User Experience and Usability in Agriculture – Selected Aspects for Design Systems

Jakub Štěpán Novák¹, Jan Masner¹, Jiří Vaněk¹, Pavel Šimek¹, Klára Hennyeyová²

¹Department of Information Technologies, Faculty of Economics and Management, Czech University of Life Sciences Prague, Czech Republic

² Department of Informatics, Faculty of Economics and Management, Slovak University of Agriculture in Nitra, Slovak Republic

Abstract

The paper focuses on the analysis of the applicability of usability and UX methods in the development of applications intended for use in the agrarian sector. In addition to an overview of methods and approaches suitable for this purpose, the process of advanced adoption of the UX methods in the development of agrarian software products is also described. The article also discusses ways to enable partially automated, time-efficient, and cost-effective solutions for the creation of interfaces for agricultural applications. Possibilities of future development and technologies related to the usability of products in agriculture are also outlined. The article thus covers the concept for optimizing the development of agricultural products. The main contribution is the input analysis for the future development of the agrarian design system. From such a synthesized system design, it is then possible to create application interfaces that should have seamless usability and good UX.

Keywords

UX, Usability, Agriculture, Design System, Automation, UI, SW, Digital product.

Novák, J. Š., Masner, J., Vaněk, J., Šimek, P. and Hennyeyová, K. (2019) "User Experience and Usability in Agriculture - Selected Aspects for Design Systems", *AGRIS on-line Papers in Economics and Informatics*, Vol. 11, No. 4, pp. 75-83. ISSN 1804-1930. DOI 10.7160/aol.2019.110407.

Introduction

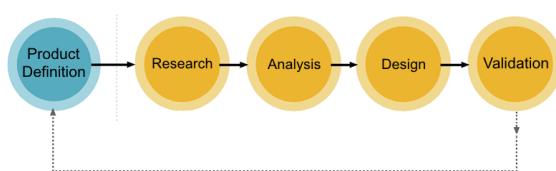
User Experience

User Experience (UX) is a phenomenon currently emerging in connection with any product intended for consumption and control by users (Hassenzahl and Tractinsky, 2006). The term UX and its use does not have a long history, but the true core of this new scientific discipline dates back to times when there were no computers, let alone the sophisticated software products that UX is currently dealing with (Getto, et al., 2013). Now, this term is primarily related to the optimization of application development, specifically their user interface (Saavedra, et al., 2019). Thanks to this connection, UX now stands for application development, which greatly limits the domain of this industry. At the core, UX deals with everything that somehow affects users during product interaction, especially at the emotional level (Kuusinen, et al., 2012). It does not have to be just a software product interface. For example, a coffee shop may also have a good UX where the entire process

from ordering coffee to consumption to exiting the establishment leaves a pleasant feeling in the customer (Pauls, 2013). A bad user experience can be associated with unpleasant and unnecessary bureaucracy and inconvenient processes when visiting the office. In a similar way, a user can take away any user experience, for example from a software product, whether positive, when the product does exactly what the user expects without unnecessary hurdles and intuitively helps him achieve the goal (Ceccacci and Giraldi, 2016). Or, on the contrary, an application can be remembered due to its painful logic even years after its last use. In all these cases we can talk about user experience. However, in order to be able to effectively monitor, measure and effectively apply this information to product development and subsequent iterations, many specialized disciplines are required. It is these different disciplines that are covered by one overarching term, called UX (Sivaji, et al., 2016).

Basically, UX combines the fields of information architecture, psychology, analytics, design,

and testing (Rosenberg, 2018). Variable aspects of these disciplines are utilized across the UX process cycle, which has the most general form of discovery - identifying needs, facts and additional information, followed by a design process using various design methods, completing the process with testing of created designs and validating hypotheses. This process is repeated in iterations until an ideal result is obtained as a seamlessly usable product (Hartson and Pyla, 2012). The UX process is shown in Figure 1.



Source: theblog.adobe.com

Figure1: UX process.

Usability

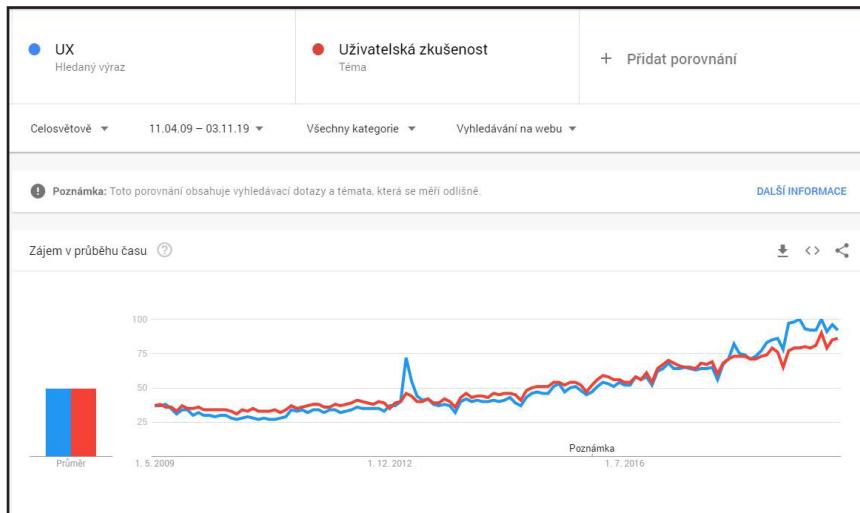
One of the building blocks of UX is usability, which is often confused with UX. However, the fact remains that usability is only one aspect of UX (Tullis and Albert, 2013). Usability describes how well, intuitively the product can be used, while usability also monitors how the product interaction side meets the standards and requirements of disabled users (Finstad, 2010) (Pétrie and Bevan, 2009). The overall rememberability and teachability of the interface is also strongly influenced by the overall usability of the product (Rusu, et al., 2015).

Usability and UX in agriculture

In recent years, the usability of products as well as the focus of companies on UX has greatly improved and this trend of adaptation to product quality and usability has been increasing (Šimek, et al., 2015). The evolution of interest over ten years is shown in Figure 2. However, agriculture and agricultural software products, in particular, are still lagging behind in terms of usability and quality compared to other specialized products, mainly due to the lack of acceptance of modern SW and UX developments the industry (Ranasinghe, et al., 2019).

In order to satisfy the high interest in UX, it is necessary to define various methodologies, which will help to anchor UX and allow for the associated higher product quality. As already illustrated in Figure 1, the UX process has many phases, with a plethora of methods applicable in each phase. The list below captures the commonly used method groups including both old and modern methods:

- **Questionnaire surveys.** The fastest, cheapest, and the most convenient way to receive feedback. In the agricultural sector, due to the geographical size of the user group, this method is very suitable for the initialization of development bases (Hinderks, et al., 2019).
- **Deep-dive interviews.** A method that relies heavily on psychology. The main task is not to test but to identify the needs of the user that are not obvious at first sight (Wilson, 2014).
- **Laboratory testing.** Specific application test data is best obtained from laboratory



Source: Authors @ GoogleTrends

Figure 2: Development of UX and usability interest between 2009-2019.

testing. The laboratory alternative is an adequately equipped PC. From this kind of testing, data is obtained primarily through eye movement, eye and click heatmap, user's facial expressions and different biometric indicators (Wittenberg, et al., 2019).

- **Design Systems.** A method of creating AI that excels in achieving perfect consistency of the user interface and thus strongly supports the usability of the whole product (Churchill, 2019).

Poor product usability in agriculture often results in confusing information for businesses, inefficient production, and resource management, and finally, a strong negative financial impact (Hussein, et al., 2014). Smaller firms of any kind are also facing this problem. These problems are greatly reduced thanks to newly applied methods and procedures that support UX adaptation and the associated higher product quality. Moreover, by keeping UX application costs low and usable, they make them more accessible and, above all, better graspable (Kujala, et al., 2011). UX in agriculture currently works well, for example, with physical controls and instruments (Trivelli, et al., 2019). However, agricultural software solutions lack UX. This is mainly due to the very narrow focus of this direction, the target user group and the resources allocated to the development of these products (Witteveen, et al., 2017). For example, automation of development processes or open and accessible libraries containing ready-made components and proven solutions to problematic aspects of agricultural system AIs can help improve this situation. One option could be to create an agrarian design system.

Development possibilities for usability and UX in agriculture

In addition to conventional applications, the agricultural sector can also benefit from virtual and augmented reality technologies. Cases where an agricultural worker can receive relevant information in real time through smart glasses allow for new applications and with them new challenges in the usability testing and development of these solutions (Huuskonen and Oksanen, 2018).

Prominent areas of augmented reality in agriculture:

- Field monitoring and detection of pests and insects
- Soil analysis, recommendation of specific crops for specific parts of the field

- Virtual tours without the use of physical agricultural equipment

These technologies lead to an ideal usability scenario. Thus, to an interface that the user is not even aware of, the interface intuitively transmits value to it in the form of readily available relevant information. Testing of these devices relies heavily on monitoring eye movement and gyroscopic movement indicators of the user (Barricelli, et al., 2018).

Materials and methods

The article focuses on the analysis of methods and procedures in the field of using UX for the development of agrarian sector SW products and relies heavily on existing long-term research of the Department of Information Technologies of the CULS Prague in areas of testing, automation and creation of usability support systems. The aim of this article is to identify appropriate methods, describe the prerequisites for the creation of a high quality UX product page, and also to define a methodology that would allow the rapid and efficient deployment of UX and SW usability as a common part of agricultural solutions. Consequently, the agricultural sector could also reach the level of others in application usability, and it would be possible to develop application interfaces in a cost-effective and high-quality environment in any farm size environment.

The article builds upon the knowledge obtained from scientific literature and the study of behavioural patterns of the agrarian user base. Furthermore, the methods of user needs determination and rapid verification of hypotheses were used. The article serves as an introductory study for the future methodology of creating an agrarian design system.

The research analysed data from the following methods and procedures:

- Methods of testing the usability of applications focusing on agriculture
- Demographic investigation of behaviour and requirements
- Concept and creation of design systems

Usability testing

As part of the long-term research activity of DIT in the creation of various agrarian applications, the target group was presented with various scenarios and versions of agrarian-oriented portals with different levels of usability. This means

that users have interacted with portals that have notoriously poor usability, as well as with portals that have been rated as very good in the past. During the interactions and completion of the scenario's steps, several reaction indicators were recorded:

- Eye tracking
- Heatmaps
- Monitoring of emotions and facial expressions (worse readability, frowning etc.)
- Mouse movement
- Heart rate
- Reaction speed

Thanks to this research it was possible to evaluate the hypotheses of usability in the agrarian sector, as well as to calibrate the methods used and to modify them to suit the sector.

Concept and creation of design systems

Knowledge of the specifics of agrarian sector users together with the described procedures can be used to develop a design system that, thanks to proven concepts, allows to create UI of agrarian software products without the need for dedicated research and design teams. With the future potential of automated front-end page compositions and rough sketch coding, the components of the final system design can be built into an interactive and immediately usable part of the product. This

possibility of designing a system and its application within the model interface of a generic application is also examined in this article.

Demographic investigation of behaviour and requirements

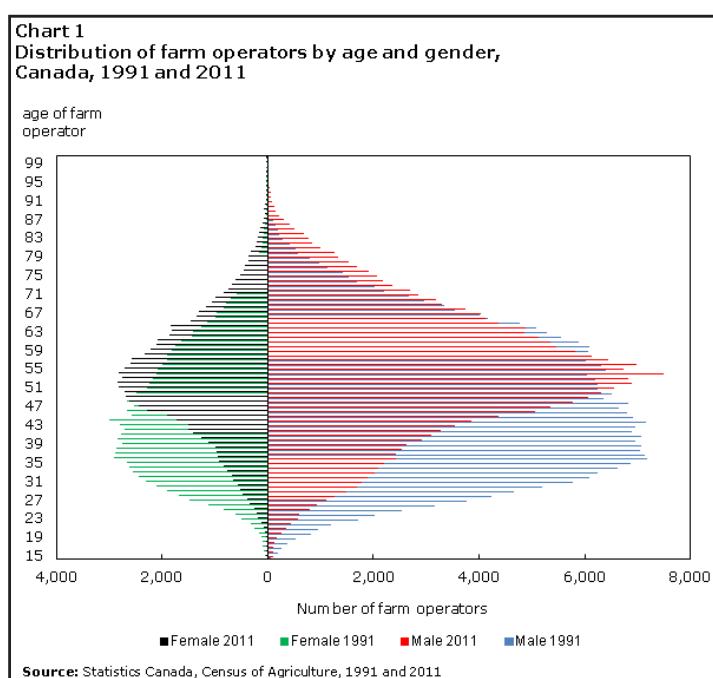
In order to effectively evaluate and prepare a quality usability page, it is crucial to know the basic structure of the target user group. Selected statistics and demographic indicators were analysed. It is well known that older populations approach software products differently and have specific requirements.

Results and discussion

Ensuring usability standards

In the case of applications for the agrarian sector, the target group of users is primarily agricultural workers. In order to get a basic overview, a demographic map can be used to identify which kinds of users need to focus primarily on in the next stages. Figure 3 shows the demographics of agrarian workers with an outline of development in time.

Men over the age of 50 have the largest representation in the target group. This finding lays the foundations for the next phase, which is identifying the specifics and patterns of this group. The specific requirements of older users



Source: Statistics Canada, Census of Agriculture

Figure 3: Distribution of workers in agriculture based on age and gender.

in terms of application usability are the contrast of interface elements, the size and readability of the elements, the clarity of actions, and compatibility with web usability assistants. The availability and knowledge of technologies is also specific within this user group. Most of these users use technology primarily for office purposes and advanced information technology knowledge is average to below average (Vaněk, et al., 2016). Moreover, the places where these users are located often have a worse and slower Internet connection, which must be considered when optimizing applications while adapting remote testing capabilities (Vaněk, et al., 2009).

Evaluation of methods suitable for agriculture

All the above requirements must be considered when designing the UX testing procedure and then selecting the method for product creation. Table 1 shows a list of selected research methods suitable for testing the needs of users of agrarian applications, including the degree of their acceptance and the benefits of the findings.

Method	Level of acceptance	Benefit of results
Questionnaire Surveys	90%	6/10
Remote usability testing	70%	8/10
Deepdive interviews	55%	7/10
Laboratory usability testing	35%	9/10

Source: Authors

Table 1: Selected UX research methods for agriculture.

The first column of Table 1 contains selected methods that were evaluated as the most suitable and are further evaluated against each other. The second column of the table describes the acceptance rate of the individual methods, i.e. how many surveyed users are willing to undertake research using this method. The last column with the benefit values declares a score indicating how much the results obtained by the method are beneficial for design, iteration, and overall development with respect to the time costs associated with the method.

Questionnaire surveys

Among the users the most accepted method of information discovery. Thanks to its low time-consumption and resources required, this method suited all users. Since there is no need for a powerful device, fast internet or physical presence, 90% of the addressed users participated in this research. The benefit of this method was mainly to identify surface needs, problems and specifics from situations associated with the use

of agrarian applications. The knowledge obtained served as a basic building block for the next phases of research.

Remote usability testing

A method that made it possible to collect very important information through specific scenarios and application interactions. Because the method is based on two-way video transmission, the demands on the Internet connection and the performance of the device was higher than the questionnaire. The average time consumption per user in this case was 30-40 minutes, which is a noticeable difference compared to 5 minutes for the questionnaire. For this reason, only 70% of the addressed users were willing to undergo this testing method. The benefits were very high, as users were able to comment on their feelings and frustrations in interaction as they went through specific situations. In addition to the classic scenario, a 5-second test, a first-click test and a blank test were also included in this kind of testing.

Deep-dive interviews

Usability testing was complemented by deep-dive interviews that helped identify the inner motivations of this user group and other hidden contexts and problems related to interactions within the agrarian sector. Like remote usability testing, this method was more time-consuming, and it could be annoying to certain users due to more detailed questions. Nevertheless, thanks to 55% attendance, this method brought very valuable insights into the daily routines and problems of the agrarian target group.

Laboratory usability testing

The least accepted but most beneficial method. Because this method requires the physical presence of the user in a special laboratory and the time-consuming logistics of getting multiple users involved, the willingness to undergo this method is only 35%. KIT research shows that this is significantly lower than other groups (such as office workers). The benefit of this testing was by far the biggest, because the special technique was used to capture detailed properties of interactions compared to remote testing. This included eye movement, positioning and visual elements through nonverbal reactions.

Based on these values, it was possible to determine which elements and in what form best suited to users in different scenarios. The testing also revealed the expected composition of generic information structures, interactions, and the overall nature of interface semantics. All this information is

by default used to design the application interface and iterate to reach the final form. However, in order to facilitate and accelerate the creation of agrarian applications, it might also be necessary to create an agricultural design system that will ensure the required level of usability.

Concept of possible design system solution

One of the main parts of the design system are UI components, which are enriched in the design system by other aspects such as recommendations for use and taxonomy, colour combinations, behaviour and more. The architecture of the system design is shown in Figure 4.

The proposed UX agrarian design system has the following structure:

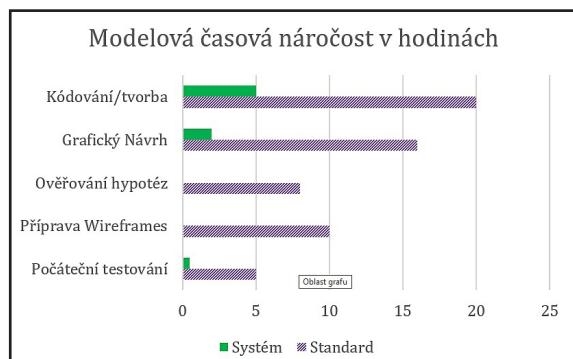
- Visual layer. Basic description of typography, recommended contrasts, offset, colour combinations and their place of usage. This site is variable to be easily customizable for the brand and needs of individual entities.
- Component Library. It contains finished interface elements in both visual and code form. These include tables, navigation bars, tabs, buttons, and more. These elements can be used to create the structure of any application and visualize the architecture depending on given brand.
- Additional rules. For example, taxonomy and other information about when and where it is appropriate to use what elements. What to avoid and in which cases to give preference to a certain component.

All this information in the created system is based

on user research and together they form a harmonious tool for creating usable agrarian applications.

Composition of model application using Design system

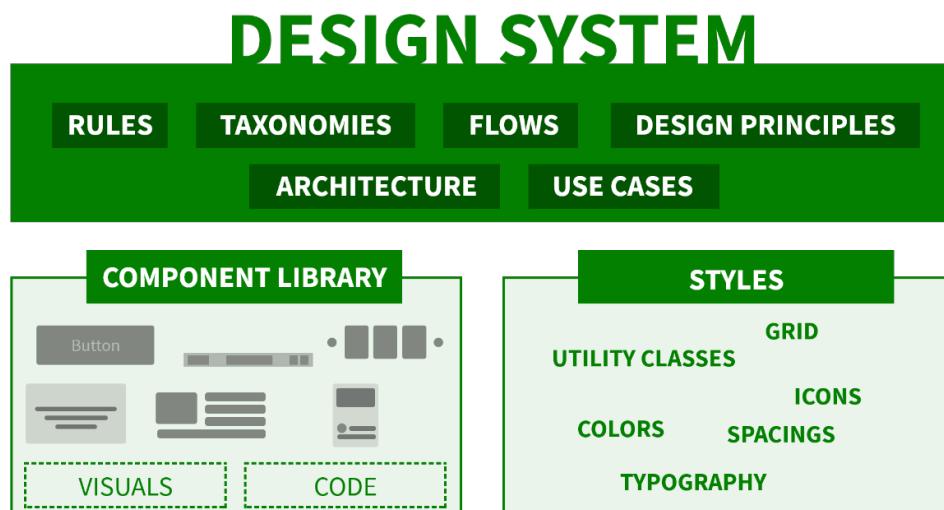
From the synthesized design of the system it is possible to create the user interface of the application, which should have smooth usability. Since in addition to the components, the system also includes location recommendations and ways of using individual elements, initial user research is not necessary. To illustrate efficiency, a second version of the application was created using a standard process. The new version uses the generic design system. Figure 5 shows a comparison of the time required for each stage of development using a standard procedure and development using a proposed agrarian design system.



Source: Authors

Figure 5: Time resources by development phases.

The table shows noticeable differences in time demands of individual phases. Because the system



Source: Authors

Figure 4: Agricultural Design System Architecture.

design is based on the lessons learned from verifying usability hypotheses, there is no need to spend any time in the phases associated with testing and initial conception. Thanks to the finished components, the implementation phases of the design system process are also significantly shorter. In this case, the most demanding is the composition of the interface and the coding of the additional functions. Subsequent adjustments such as interface colouring are very fast due to usage of variables. In the traditional procedure, the components must first be drawn and coded from scratch. Creating a model interface using a design system took less than 8 hours, while the traditional process took almost 60 hours. The application of this procedure can therefore, thanks to its low resource requirements, help to develop more and better usable applications for the agrarian sector.

Conclusion

Research has shown that the most suitable methods for testing UX and usability in the agrarian sector are questionnaire survey, remote usability testing, deep-dive interviews, and laboratory usability testing. Using these methods, it is possible not only to create good quality agrarian applications, but also to build the foundations of an agrarian design system, which in the future has the potential to elevate the development of these applications to a higher level. Mainly thanks to the potential of system design based on the usability standards of the agrarian sector, it is possible to create user

interfaces with very good UX very effectively. The strong point is that this system can be used by anyone without the necessary expertise in the field of usability and UX. The combination of time efficiency, ease of grasping, and the foundations of proven hypotheses make this tool a force that has the potential to stir the applicability of agrarian sector applications in the right direction.

The potential future combination of this agrarian design system together with the automated composition of UI interfaces could be a breakthrough in creating not only interfaces of agrarian applications. The detailed impact on the perceived quality of usability of the interfaces created this way, together with the economic implications in more complex scenarios, will be the subject of future research. The main benefit should be to simplify the creation of agrarian applications in any environment while achieving high usability and quality.

Acknowledgments

The results and knowledge included herein have been obtained owing to support from the following institutional grants. Internal grant agency of the Faculty of Economics and Management, Czech University of Life Sciences in Prague, grant no. 2019A0011 – “Automated classification of user action within laboratory usability testing and UX.

Corresponding authors

Jakub Štěpán Novák

Department of Information Technologies, Faculty of Economics and Management

Czech University of Life Sciences Prague, Kamýcká 129, 165 00 Prague-Suchdol, Czech Republic

E-mail: novakjakub_stepan@fef.czu.cz

References

- [1] Barricelli, B. R., de Bonis, A., Di Gaetano, S. and Valtolina. (2018) “Semiotic framework for virtual reality usability and ux evaluation: A pilot study”, *CEUR Workshop Proceedings*. ISSN 16130073.
- [2] Ceccacci, S. and Giraldi, L. (2016) “Product usability: Is it a criterion to measure "Good UX" or a prerequisite?”, *Proceedings of the ASME Design Engineering Technical Conference*. ISSN 00002008. DOI 10.1115/DETC2016-59500.
- [3] Finstad, K. (2010) “The Usability Metric for User Experience”, *Interacting with Computers*, pp. 323-327. E-ISSN 1873-7951. ISSN 0953-5438 DOI 10.1016/j.intcom.2010.04.004.
- [4] Getto, G., Potts, L., Salvo , M. J. and Gossett, K. (2013) “Teaching UX: designing programs to train the next generation of UX experts”, *Proceedings of the 31st ACM international conference on Design of communication*, pp. 65-70. ISBN 978-1-4503-2131-0. DOI 10.1145/2507065.2507082.
- [5] Hartson, R. and Pyla, P. S. (2012) “*The UX Book*”, Morgan Kaufmann. ISBN-13 978-0123852410.

- [6] Hassenzahl, M. and Tractinsky, N. (2006) "User experience - A research agenda", *Behaviour and Information Technology*, pp. 91-97. ISSN 13623001. DOI 10.1080/01449290500330331.
- [7] Hinderks, A., Schrepp, M., Mayo, F. J. D., Escalona, M. J. and Thomachewski, J. (2019) "Developing a UX KPI based on the user experience questionnaire", *Computer Standards and Interfaces*, Vol. 65, pp. 38-44. ISSN 0920-5489. DOI 10.1016/j.csi.2019.01.007.
- [8] Hussein, I., Mahmud, M. and Md Tap, A. O. (2014) "HCI Knowledge for UX Practices in the Web Development Process", *International Conference of Design, User Experience, and Usability*, pp. 116-126. DOI 10.1007/978-3-319-07626-3_11.
- [9] Huuskonen, J. and Oksanen, T. (2018) "Soil sampling with drones and augmented reality in precision agriculture", *Computers and Electronics in Agriculture*, Vol. 154, pp. 25-35. ISSN 0168-1699. DOI 10.1016/j.compag.2018.08.039.
- [10] Churchill, E. (2019) "Scaling UX with design systems", *Interactions*, pp. 22-23. E-ISSN 1558-3449, ISSN 1072-5520. DOI 10.1145/3352681.
- [11] Kujala, S., Roto, V., Väänänen-Vainio-Mattila, K., Karapanos, E., Sinnelä, A. (2011) "UX Curve: A method for evaluating long-term user experience", *Interacting with Computers*, Vol. 23, No. 5, pp. 473-483. DOI 10.1016/j.intcom.2011.06.005.
- [12] Kuusinen, K., Mikkonen, T. and Pakarinen, S. (2012) "Agile user experience development in a large software organization: Good expertise but limited impact", In: Winckler M., Forbrig P., Bernhaupt R. (eds) *Human-Centered Software Engineering*. HCSE 2012. Lecture Notes in Computer Science, vol 7623. Springer, Berlin, Heidelberg, pp. 94-111. ISBN 978-3-642-34346-9. DOI 10.1007/978-3-642-34347-6_6.
- [13] Pauls, J. (2013) "The pathology of everyday things - Stairways – Revisted", *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, pp. 580-584. E-ISSN 1071-1813, ISSN 2169-5067. DOI 10.1177/1541931213571124.
- [14] Pétrie, H. L. and Bevan, N. (2009) "The evaluation of accessibility, usability, and user experience", In: *The Universal Access Handbook*, CRC Press, pp. 20-1-20-16. ISBN 9780805862805.
- [15] Ranasinghe, C., Pfeiffer, M., Heitmann, S. and Kray, C. (2019) "Evaluating User Experience under Location Quality Variations: A Framework for in-the-wild Studies", *Proceedings of the 21st International Conference on Human-Computer Interaction with Mobile Devices and Services*. ISBN 978-1-4503-6825-4. DOI 10.1145/3338286.3344392.
- [16] Rosenberg, D. (2018) "The business of UX strategy", *Interactions*, pp. 26-32. E-ISSN 1558-3449, ISSN 1072-5520. DOI 10.1145/3181372.
- [17] Rusu, C., Rusu, V., Roncagliolo, S. and González, C. (2015) "Usability and User Experience: What Should We Care About?", *International Journal of Information Technologies and Systems Approach*, Vol. 8, No. 2, pp. 1-12. ISSN 1935-570X. DOI 10.4018/IJITSA.2015070101.
- [18] Saavedra, M.-J., Rusu, C., Quiñones, D. and Roncagliolo, S. (2019) "A Set of Usability and User eXperience Heuristics for Social Networks", Conference paper In book series *Lecture Notes in Computer Science*, pp. 128-139. DOI 10.1007/978-3-030-21902-4_10.
- [19] Sivaji, A., Nielsen, S. F. and Clemmensen, T. (2016) "A Textual Feedback Tool for Empowering Participants in Usability and UX Evaluations", *International Journal of Human-Computer Interaction*, Vol. 33, No. 5 pp. 357-370. E- ISSN 1532-7590, ISSN 1044-7318. DOI 10.1080/10447318.2016.1243928.
- [20] Šimek P., Vaněk J., Pavlík J. (2015) "Usability of UX Methods in Agrarian Sector – Verification", *AGRIS on-line Papers in Economics and Informatics*, Vol. 7, No. 3, pp. 49 – 56. ISSN 1804-1930. DOI 10.7160/aol.2015.070305.
- [21] Trivelli, L., Apicella, A., Chiarello, F., Rana, R., Fantoni, G. and Tarabella, A. (2019) "From precision agriculture to Industry 4.0: Unveiling technological connections in the agrifood sector", *British Food Journal*, Vol. 121, No. 8, pp. 1730-1743. ISSN 0007-070X. DOI 10.1108/BFJ-11-2018-0747.

- [22] Tullis, T. and Albert, B. (2013) “*Measuring the User Experience*”, Morgan Kaufmann, 320 p. ISBN-13 978-0124157811.
- [23] Vaněk, J., Očenášek, V., Stočes, M., Masner, J. (2016) “Adoption of modern ICT in regional perspective – situation in the Czech Republic”, *Proceedings of the 16th International Scientific Conference Globalization and its socio-economic consequences 05.10.2016*, GEORG, Zilina, Slovak Republic, pp. 2291-2298. ISSN 2454-0943. ISBN 978-80-8154-191-9.
- [24] Vaněk, J., Jarolímek, J. and Šimek, P. (2009). “Information Services and ICT Development in Agriculture of the Czech Republic”, *Agris on-line Papers in Economics and Informatics*, Vol. 1, No. 1., pp. 1-5. ISSN 1804-1930.
- [25] Wilson, C. (2013) “*Interview Techniques for UX Practitioners: A User-Centered Design Method*”, Morgan Kaufmann, 122 p. ISBN 9780124103931.
- [26] Wittenberg C., Bauer B., Stache N. (2019) A Smart Factory in a Laboratory Size for Developing and Testing Innovative Human-Machine Interaction Concepts. In: Ahram T., Falcão C. (eds) *Advances in Usability and User Experience*, AHFE 2019, Advances in Intelligent Systems and Computing, Vol. 972, Springer, Cham. E-ISBN 978-3-030-19135-1, ISBN 978-3-030-19134-4. DOI 10.1007/978-3-030-19135-1_16.
- [27] Witteveen, L., Lie, R., Goris, M. and Ingram, V. (2017) “Design and development of a digital farmer field school. Experiences with a digital learning environment for cocoa production and certification in Sierra Leone”, *Telematics and Informatics*, Vol. 34, No. 8., pp. 1673-1684. ISSN 0736-5853. DOI 10.1016/j.tele.2017.07.013.