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Modelling in Dynamic User Experience Design of Educational Toys Packages

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Abstract. The positive emotional impact of a product on the consumers raises their desire to own it. A hybrid framework for emotional user experience package design of educational toys was created. It combines traditional static with new dynamic user experience design. A questionnaire for measuring traditional static user experience was created. Dynamic emotional user experience is measured by new real time data collection technology. It provides dynamic user performance metrics data. By a swarm optimization model optimal values of package design elements providing most positive emotional user experience are determined. This was used for defining user experience recommendations for package design of educational toys and tools. A comparison of dynamic user experience design with traditional static user experience design of packages shows the advantages of this new technology enabling better package design. Further development recommendations for dynamic user experience design of packages are defined.

INTRODUCTION

In the real and virtual world exist experiencing rising levels of visual information and noise [1, 2, 16]. In such surrounding it is very important to understand which methods and tools to use in the design work so that to notice and understand the messages to the user [5, 8, 9, 10, 17].

The main purpose of any design work is to familiarize the user with the best product qualities. Causing positive emotions in the consumers will increase their desire to own specific product. The positive emotional response of the users means that the marketing signals have been transmitted successfully, that the positive result is significant and is responsible for the desired economic action. A relationship between the consumer and the product has been established [1, 7, 15, 16].

In this article samples of packages of educational toys are considered as combination of design elements that can influence users' emotions. Data about the emotional states of the users are collected in two ways: by questionnaires and by specialized devices measuring real time the dynamic user experience [5, 8, 9, 10, 17, 18]. An optimal model for processing emotional user experience results is needed. Combinations of visual design elements that provide most positive emotional response should be selected [1, 2, 15, 16]. Guidelines for new packages of educational toys and tools, based on these combinations are created. The new inspiring educational toys and tools packaging will ensure the most positive response of the users.

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FRAMEWORK FOR USER EXPERIENCE DESIGN OF EDUCATIONAL TOYS PACKAGES

In the following a framework for user experience design of packages is presented (cf. fig. 1). It studies static and dynamic emotional user experience with educational toys package designed to create optimal package. Initially the framework determines the package design elements. It defines samples of competing packages by help of which can be collected data for traditional static design by questionnaire and for dynamic design by a special tool. By analysis of data gathered optimal package design element values are determined. These values enable the define design recommendation and implementing them into design of optimal packages.

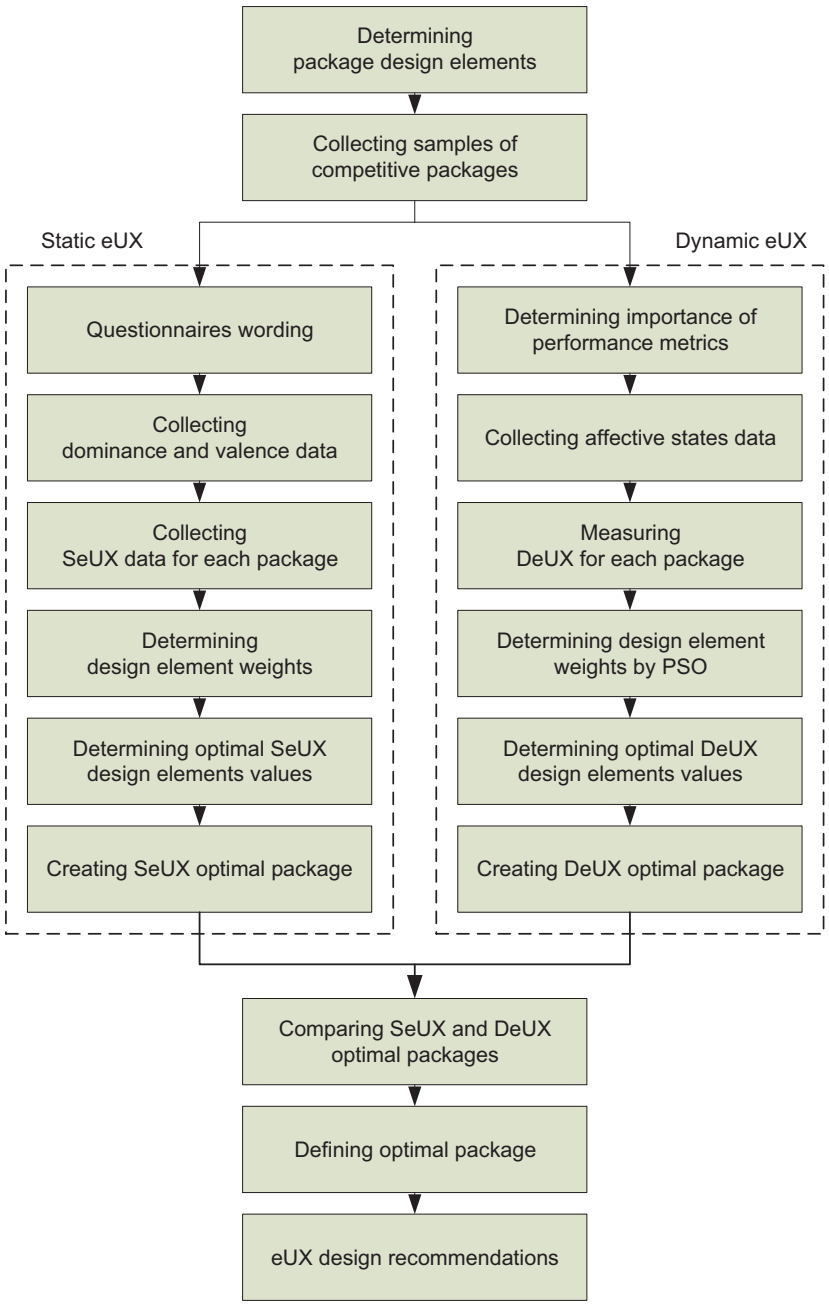

FIGURE 1. Framework steps

At first framework step a mix of interrelated package design elements are determined which is expected to affects consumer emotions [1, 2, 15, 16]. For this purpose basic package design elements like: shape, colour, line, texture, main image, logo, typography are defined. In addition main marketing elements like signs for: handmade toy, origin, additional educational advantages, laboratory tested, medically approved, etc. are determined.

At second framework step samples of competing educational toys packages according to the following criteria are selected: 1) The number of packages greater than the number of design elements; 2) Approximately same purpose and peculiarities like educational cards, letters, numbers, straining shapes.

At next seven framework steps static emotional user experience (SeUX) and dynamic emotional user experience (DeUX) with toys packages are measured and data gathered analyzed. Based on these analyses SeUX and DeUX optimal packages are designed. Further both SeUX and DeUX package designs are compared and optimal package design defined. Recommendations and guidelines for design of optimal package are determined.

MEASURING STATIC EMOTIONAL USER EXPERIENCE

For conducting emotional static user experience study [5, 8, 9, 10, 17, 18] tools like questionnaires about the valence and dominance of each design element and about the general users' rating of the packages are created. By help of questionnaires data about users' emotions is collected. On fig. 2 a model for measuring static emotional user experience is shown. Static emotional user experience value (SeUX) for each package is determined. The weight of each design element is calculated. Best design elements combination is created.

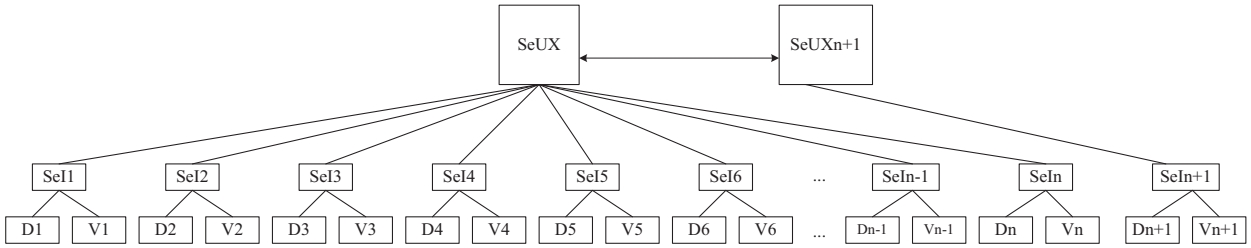

FIGURE 2. Static Emotional User Experience Measuring Model

The static emotional user experience design study starts with questionnaire wording. There are more than 100 different methods for measuring user experience. The most commonly used tools in those tasks are the questionnaires [5, 10, 17]. There are over 20 types of questionnaires. They are based on methods like Aesthetic scale, Hedonic utility scale, Game experience, Mental effort, Product semantic analysis, etc.

Three-part questionnaire is created. The steps of questionnaire creating are shown on fig. 3.

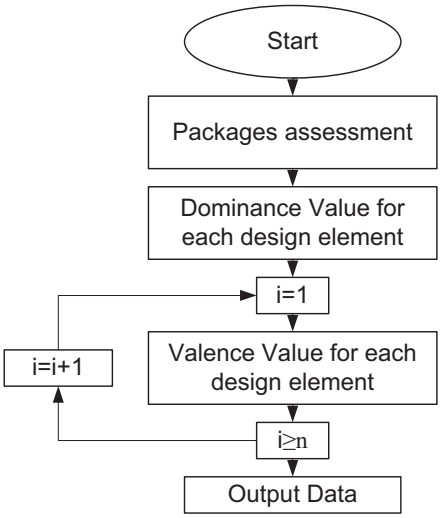

FIGURE 3. Questionnaires Creating Steps

The first part of the questionnaire presents to consumers all the selected package samples in one sheet. The users must give these packages a value from 0 (horrible) to 10 (magnificent). Further the values are transformed in the scale [0, 100].

The second part of the questionnaire presents the type of selected design elements of the package. The user has to determine how strong the design element influences the decision to buy a product. The value scale is [0,10] (0 is "absolutely unimportant", 10 is "most decisive").

The third part of the questionnaire presents all packages with their variations of the chosen design elements. The goal is the consumers to evaluate the attractiveness, overall impression (valence) of these design elements. Each user gives a value for "like-dislike" from 0 to 10 (0 is "absolutely disgusting", 10 is "unbelievable").

The first part of the questionnaire determines the general user experience value in range [0,100], noted as static emotional users' experience value ($SeUX_i$). SeUX for each package is recorded. Using the domination (D) and valence (V) parts of the questionnaire, two values for each design element are obtained. This multiplication shows the value of the static emotional impact of design element on the user SeI_i (cf. 1).

$$SeI_i = V_i D_i \tag{1}$$

The goal is to find optimal combination of the design elements maximizing the static emotional user experience with new package (SeUXn+1).

MEASURING DYNAMIC EMOTIONAL USER EXPERIENCE

As opposed to static emotional user experience measuring approach, there is not a two-dimensional coordinate system for measuring the dynamic user experience to provide data for the dominance and attractiveness of each individual design elements. The dynamic performance metrics whose numeric values present four separate characteristics of the users' emotional state during product evaluation process: Focus, Engagement, Arousal and Valence (Like/Dislike). The aggregated combination of these metrics influencing users' emotions present common dynamic emotional influence value (DeI). The combination of all design elements influence values determines the common user experience value of the package (DeUX) shown on fig. 4.

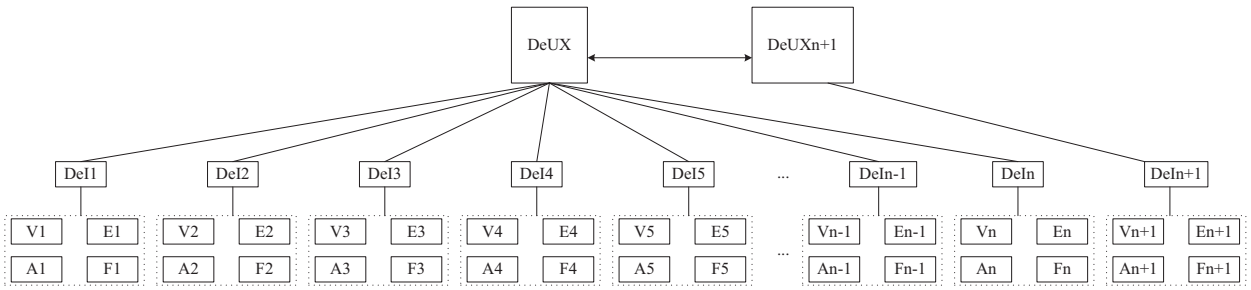

FIGURE 4. Dynamic Emotional User Experience Measuring Model

For analyzing performance metrics data within marketing area these four emotional states cannot be represented as a separate degree of significance/importance. They can be presented as a sequential logical chain of actions, cf. fig. 5a. This sequence can also be illustrated like the so-called "Marketing funnel" scheme or AIDA model [11, 12], cf. fig. 5b.

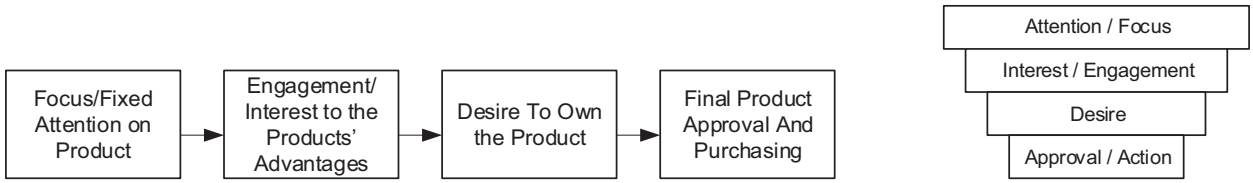

FIGURE 5. Logical chain of action in users' behavior (a) and AIDA marketing model (b).

The AIDA model is the best and most comprehensible model of classical marketing models for illustration of users' emotional state in the process of product acquisition. At first step (the top of the funnel) of the marketing scheme the smallest effort is required for success achieving and the largest number of users are attracted. At the last step the smallest number of users is reached, so efforts to boost consumer emotions in this part of the process are the strongest.

By AIDA scheme and expert opinion of user experience designers about four performance metrics the following weights are given:

Focus (F) – 12%, Engagement (E) – 16%, Arousal (A) – 24%, Valence (V) – 48%.

In order to aggregate the performance metrics values into a dynamic user experience score for each design element within the range [0,100], the dynamic emotional influence (DeI_i) of each individual elements is calculated by formula (2):

$$DeI_i = (0{,}12F_i + 0{,}16E_i + 0{,}24A_i + 0{,}48V_i) \quad (2)$$

The goal is to find optimal combination of the design elements for which the dynamic emotional user experience of the new package (SeUXn+1) is maximized.

ANALYZING DATA FROM STATIC AND DYNAMIC USER EXPERIENCE STUDY

For determining optimal user experience design method for educational toys packages, the weights of the design elements in SeUX and DeUX cases are determined. The Particle Swarm Optimization method [3] stability for finding optimal combination of design elements is used. The results are implemented in the design of SeUX and DeUX optimal packages.

When the general users' values of every package ($SeUX_i$ and $DeUX_i$) are found and the data for emotional influences (SeI_i and DeI_i) are obtained, the weight of every design element can be calculated. For this purpose, the Partial least squares regression (PLS) method is used.

Partial least squares regression is a statistical method used for finding quantitative relationships between two types of variables. The purpose is to predict and analyze a set of dependent variables from a set of independent variables. In

this study the independent (predictor) variables X are the influence (emotional impact I) of the design elements and their categories. The dependent (response) variables Y are users' general values for every package ($SeUX_i$ or $DeUX_i$). Each dependent variable Yi from Y can be calculated from a linear combination of n independent (predictor) variables Xi in X, cf. (3), where ω_i are the regression coefficients determined, and ε denotes the error.

$$Y_i = \omega_0 + \omega_1 X_1 + \omega_2 X_2 + \ldots + \omega_n X_n + \varepsilon \quad (3)$$

In the emotional user experience measuring model there is only one dependent variable – general user value ($SeUX_i$ or $DeUX_i$). So the n-estimator of regression coefficients is $B = (X^T X)^{-1} X^T Y$.

When the regression coefficients ("weights") for every design element influence are obtained, we use Particle Swarm Optimization model for finding optimal combination of design elements, which maximizes the positive influence on users.

Swarm Intelligence algorithm is built on the idea of optimization modelling inspired by the nature. This approach simulates collective behavior of group of agents like birds, ants, fishes, bees. The social order of interacting agents working by set of responses is being considered like a bigger hyper-mind. Such interaction has to be based on permanent positive and negative feedback, exchange of experience and continuous work that does not depend on each separated agent [4, 6]

For this study the most appropriate are swarm intelligence methods like Particle Swarm Optimization model. It is based on upgraded and optimized Partial-Least Squares regression (PLS) model characterized by precision and stability [3, 14].

The steps of the PSO-model can be presented in the following order:

- The appropriate design elements and their categories are chosen and their weights presented as dependent variable $X = (x_i^1, x_i^2, \ldots, x_i^d)$, which determines the position of each particle i of N in D-dimension target searching space (N - number of existing particles in this space).

  The historical optimal position is determined like $P_i = (P_i^1, P_i^2, \ldots, P_i^d)$. The optimal found position is determined like $Pg = (P_g^1, P_g^2, \ldots, P_g^i)$. The speed of the particle i is determined like D-dimension vector $V = (v_i^1, v_i^2, \ldots, v_i^d)$.

  PSO is an arithmetic model based on iteration. It calculates particles corresponding positions (cf. 4).

$$V_{id}^{k+1} = V_{id}^k + c_1 r_1 (p_{id}^k - x_{id}^k) + c_2 r_2 (p_{gd}^k - x_{gd}^k) \quad (4)$$
$$X_{id}^{k+1} = X_{id}^k + V_{id}^{k+1}$$

  Where $1 \le i \le N$; $1 \le d \le D$; k (iteration time) ≥ 0;
  c_1, c_2 (acceleration constants) ≥ 0;
  $0 \le r_1, r_2 \le 1$ (random number, uniformly distributed);
  vmax = const.
- The constraints are determined and function is trained, cf. (5)

$$\min f(x) = \omega_1 \min f_1(x) + \omega_2 \min f_2(x); \ \omega_1 + \omega_2 = 1 \quad (5)$$

  where ω_1, ω_2 are the trial fixed weights;
  $\min f_1(x) = \frac{1}{m} \sum_{i-1}^{m} [(y_{ni} - y_i)/y_i]$ is the minimum fitting relative error;
  $\min f_2(x) = \frac{1}{m} \sum_{i-1}^{n} [(y_{di} - y_i)/y_i]$ is the minimum reserved inspection relative error;
  m-sample size; n-reserve inspection sample size; y_{ni} – fitting value of SeUX or DeUX; y_{di} – reserved inspection value of SeUX or DeUX; y_i – measured value of SeUX or DeUX.
- The process is fixed on and the control parameters of PSO is determined.
- Optimization model is used and the results is obtained.

Based on PSO-model, the most appropriate variants of the design elements that have the most positive static and dynamic emotional impact on consumer experience were determined.

OPTIMAL USER EXPERIENCE DESIGN PACKAGE

The optimal design elements results obtained from SeUX and DeUX methods are merged into two new packages combination (N+1 and N+2). These compositions present a supposed optimal design solution for educational toys package. According to user experience design rules, the results must be subjected to a follow-up study to: 1) prove which of the two methods can be considered more successful and 2) chose optimal UX-design package for educational toys.

Both optimal packages are subjected to a new emotional user experience study based on SeUX and DeUX methods. The same users are observed during this study. The results for SeUX and DeUX of the new packages N+1 and N+2 are obtained and recorded.

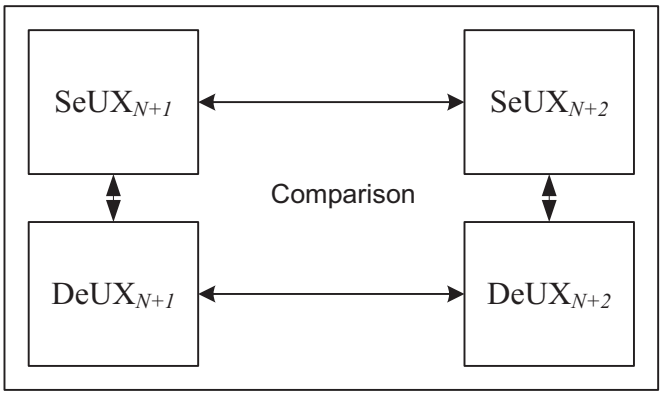

FIGURE 6. Comparing Static and Dynamic emotional UX Methods

The comparing of static and dynamic approaches for measuring emotional user experience can be described as follows (cf. fig. 6):

- In the dynamic approach the real time emotional states data directly from users is collected. Thus has made it possible to avoid subjective consumer opinion, which may be inaccurate or deliberately altered.
- In the dynamic approach four objective performance metrics are determined. They give opportunities for better understanding of users' emotions.
- The optimal approach for measuring user experience will give as a result better new package emotional user experience (SeUX or DeUX).
- The results are used on the next step of the research for creating design recommendations.

Based on the chosen method, the best values for each design element with most positive influence on consumers' experience is selected. For example, these design values are:

- Form: parallelepiped;
- Primary color: green;
- Additional color: contrasted;
- Basic image: playing child;
- Logo location: top right, etc.

These are the values of the design elements of the optimal new package. It can be considered like a best decision for creating effective and inspiring educational toys packages. Because of more objective nature it is expected that the dynamic approach will be superior compared to traditional subjective static approach.

The design elements that have highest influence on consumers' emotions are described as a part of user experience design guidelines. They are not universal and can be applied only for the population surveyed and for the selected industrial sector.

CONCLUSIONS

This article confirms that it is possible to measure emotional user experience through a static and dynamic approach. It is applicable to use both methods for emotional design of educational toys packages. Partial least squares

method and the modern particle swarm optimization model are used to analyze and process the data. Completely new packages are created, repeated studied and optimal design composition is chosen to create highest emotional influence on the users. Emotional design recommendations are defined. This research is initiating further research in this new very promising area of emotional user experience design.

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REFERENCES

1. A. Sherin, “Design Elements, Color Fundamentals: A Graphic Style Manual for Understanding How Color Affects Design”, Rockport Publishers, Beverly, USA, 2012.
2. A. W. White, “The Elements of Graphic Design: Space, Unity, Page Architecture, and Type”, Allworth Press, New York, USA, 2011.
3. B. I. Schmitt, “Convergence Analysis for Particle Swarm Optimization”, PhD Thesis, Friedrich-Alexander Universitaet, Erlangen, Germany, 2015.
4. B. S. P. Mishra, S. Dehuri and S.-B. Cho, “Swarm Intelligence in Multiple and Many Objectives Optimization: A Survey and Topical Study on EEG Signal Analysis”, Part of the studies in Computational Intelligence book series, SCI, vol. 592, Springer, 2015.
5. E. Ganglbauer, J. Schrammel and S. Deutsch, “Applying Psychophysiological Methods for Measuring User Experience: Possibilities, Challenges and Feasibility”, Human-Computer Interaction - INTERACT 2009, 12th IFIP TC 13 International Conference, Sweden, 2009.
6. H. Ahmed and J. Glasgow, “Swarm Intelligence: Concepts, Models and Applications”, School of Computing Queen’s University, Kingston, Ontario, Canada, 2012.
7. H. Zhou and X. Fu, “Understanding, Measuring and Designing User Experience: The Casual Relationship Between the Aesthetic Quality of Products and User Affect”, LNCS, vol. 4550, pp. 340-349, Springer, Heidelberg, Germany, 2007.
8. J. Sauro and J. S. Lewis, “Quantifying the User Experience: Practical Statistics for User Research”, Morgan Kaufmann, Cambridge, USA, 2016.
9. M. Latin, “Measuring and Quantifying User Experience”, UX Collective, (online) https://uxdesign.cc/measuring-and-quantifying-user-experience-8f555f07363d, last visited 24.07.2019.
10. M. Rauschenberger, M. Schrepp, M. P. Cota, S. Olschner and J. Thomaschewski, “Efficient Measurement of the User Experience of Interactive Products – How to Use the User Experence Questionnaire”, International Journal of Interactive Multimedia and Artificial Intelligence, vol. 2, no 1, pp. 39-45, 2013.
11. N. H. Sinh, “The Hierarchy Model of Advertising Effects: A Debate”, Journal of Development and Integration, 2013.
12. P. Rawal, "AIDA Marketing Communication Model: Stimulating a purchase decision in the minds of the consumers through a linear progression of steps, International Journal of Multidisciplinary Research in Social Management, vol. 1, pp 37-44, 2013.
13. T. B. Taffese, “A Review of Using EEG and EMG Psychophysiological Measurements in User Experience Research”, Master’s thesis, University of Oulu, Finland, 2017.
14. T. Li, Q. Fu, F. Meng, Z. Wang and X. Wang, “Study on Partial Least-Squares Regression Model of Simulating Freezing Depth Based on Particle Swarm Optimization”, Journal of Computers, vol. 6, no. 3, 2011.
15. V. Alervall, J. S. Saied, “Perspectives on the Elements of Packaging Design. A Qualitative Study on the Communication of Packaging”, Blekinge Tekniska Högskola, Managementhögskolan, Karlskrona, Sweden, 2013.
16. V.I. Lesnyak, “Graphic Design (Profession Basis)”, Yupiter-Impeks, Moscow, Russia, 2011.
17. All UX evaluation methods (online) http://www.allaboutux.org/all-methods, last visited 23.07.2019.
18. Emotiv Insight introduction, (online) https://www.emotiv.com/insight/, San Francisco, U.S.A., 2019.