

Postupak ocjene doktorskog rada

DOKTORAND/ICA:	Ana Svalina, mag. ing. techn. graph.
NASLOV RADA na hrv. jeziku:	Evaluacija utjecaja parametara interaktivnih mobilnih vizualizacija informacija na korisničko iskustvo
NASLOV RADA na engl. jeziku:	Evaluation of interactive mobile information visualization parameters' impact on user experience

SAŽETAK:

Vizualizacije informacija često se koriste u različitim mobilnim aplikacijama. U aplikacijama interakcija ima značajan utjecaj na korisničko iskustvo i percepciju prikazanih informacija. Unatoč širokoj upotrebi, ne postoji mnogo empirijskih istraživanja o tome kako ih čitamo i kako generiraju djelotvorne uvide. Mobilni uređaji imaju velik i nedovoljno istražen potencijal za vizualizacije podataka te postoji potreba za dizajnerskim smjernicama utemeljenim na empirijskim istraživanjima. Cilj ovog rada bio je evaluirati utjecaj parametara interaktivnih mobilnih vizualizacija informacija na korisničko iskustvo. U prvom dijelu istraživanja provedena je komparativna analiza koja je obuhvatila pregled i klasifikaciju mobilnih aplikacija prema vrstama vizualizacija koje se koriste. Navedeno pruža empirijsku osnovu za razumijevanje trenutnih praksi u industriji. U glavnom dijelu rada provedeno je empirijsko istraživanje u svrhu utvrđivanja koliko svaki parametar doprinosi korisničkom iskustvu te kakvi su odnosi tih parametara. Rezultati su pokazali da su neki parametri snažnije povezani s ukupnim dojmom i međusobno povezaniiji od drugih. Na temelju tih rezultata razvijen je regresijski model koji opisuje utjecaj ključnih parametara vizualizacija na korisničko iskustvo. Također, definirane su praktične smjernice za dizajn interaktivnih mobilnih vizualizacija informacija. Glavni doprinosi ovog rada uključuju metodologiju za evaluaciju vizualizacija na mobilnim uređajima, empirijske uvide u međusobne odnose korisničkih parametara te konkretne preporuke za dizajn. Predložene smjernice pomoći će dizajnerima stvoriti vizualizacije koje su učinkovite i upotrebljive za krajnje korisnike.

Ključne riječi: dizajn, dizajn vizualizacija, korisničko iskustvo, mobilne aplikacije, vizualizacije informacija

EXTENDED ABSTRACT:

Mobile information visualizations are often used in applications. In those applications, interaction has a significant impact on user experience. Despite their widespread use, there are not many empirical studies related to how we read visualizations and how they generate useful insights. In the field of information visualization, various areas are intertwined, and the designer must be familiar with several disciplines. Some of them are cognitive science, interaction design, visual perception and psychology. Human visual perception is based on certain laws that are important to understand when designing visual representations.

From an industry perspective, designers often conduct user tests, but they are mostly focused on specific projects. These insights are rarely systematized into scientific papers that could serve as a starting point for wider application. Therefore, research such as this one are important. Mobile devices have an insufficiently explored potential for visualizations. Also, there exists a need for design guidelines based on empirical research.

The aim of this dissertation was to evaluate the impact of parameters of interactive mobile information visualizations on user experience. The research was divided into three parts through which three set hypotheses were tested. These parts are (1) a review of the literature and previous research, (2) a comparative analysis of the use of information visualizations in mobile applications and (3) the main empirical research. Based on the analysis of all the above, the relationships between parameters and user experience were evaluated.

The first part of the study involved a literature review of existing studies on this topic. The information visualization process was described, as well as visualization literacy and types of information visualizations. Emphasis was placed on defining the parameters of information visualizations for measuring user experience. Empirical evaluation studies and evaluation methods in this area are discussed in the last part of the chapter. Different classifications were considered when developing the evaluation method and selecting the UX model for this research. Parameters that are applicable for this research and that correspond to the goal of the research were selected. Those parameters are: memorability, readability, understanding, usability, usefulness, attractiveness, engagement, and overall impression.

Although mobile information visualizations are used very often there is not much empirical research related to how we read visualizations and how they generate actionable insights. Several researchers have indicated that there is a need for guidelines for designing mobile information visualizations based on empirical research. They've also emphasized the importance of developing a proper methodology for testing interactive mobile visualizations with users.

Based on everything mentioned so far, there is a need for best practices for designing visualizations. Therefore, guidelines were formed within this research that will help designers to design interactive information visualizations for mobile devices. Previous research includes experiments related to specific types of visualizations, types of interactions, and specific application contexts, but no research covers all the above. This paper covers different visualization types that are most used within selected application contexts.

The first part of the study involved a comparative analysis. It included an overview and classification of mobile applications according to the types of visualizations used. This analysis provided a good foundation for understanding current industry practices. The methods used were analysis methods, comparative methods and classification methods. The analysis was conducted in the App Finder application for the Google Play Store for 7 app categories. The main goal was to assess the content of commercial mobile applications and identify which information visualization types are used and how frequently.

Based on the findings from the analysis, the visualizations were grouped by app category and visualization type. It was determined that information visualizations are most often found in following categories: Auto and Vehicles, Finance, Medical, Parenting, Sports, Weather, and Health and Fitness. In total, 33 different types of visualizations were identified across these categories. The ten most frequently used ones include: progress bars, bar charts, line graphs, radial bar charts, area charts, donut charts, semi-radial bar charts, heatmaps, range charts, and butterfly charts. These insights were used as a foundation for designing the test samples and surveying the state of the field.

The main part of the research involved an empirical study designed to assess the contribution of individual parameters to the overall user experience. A combination of qualitative and quantitative methods was used. Specifically, an online questionnaire and a systematic evaluation of visualizations. Subjective method was applied to compare the differences between the visualization types and the user experience. The measuring instrument was a questionnaire, and the samples were evaluated using the survey method.

After gathering the responses, the test's reliability was confirmed, the data analyzed, and statistical processing performed. The independent variables were graph type and the data set, while the dependent variables were visualization parameters. The goal was to determine how much each parameter contributes to the user experience and what the relationships between these parameters are.

The questionnaire was created using the Useberry tool, in two different versions, for group 1 and group 2. Each group was shown a different independent variable for the data set. The first part of the questionnaire included the consent, demographic and psychographic questions, and questions related to user competencies and frequency of application use. The main part focused on specific parameters being studied, and the user experience was assessed based on these. Participants were asked to complete a prototype task and answer two sets of questions. One targeting pragmatic aspects, and the other hedonic ones.

The results were analyzed in two phases. In the first phase, each user experience parameter was evaluated in relation to the variables of the data set and the visualization type. In the second phase, a deeper analysis of the relationships between the parameters was conducted, including correlation and regression analyses. The aim was to examine their connection with the overall impression and quality of the user experience.

The categories with the highest use of visualizations (Weather, Health and Fitness, Finance) were chosen as the focus of this research. For each category, the five most frequently used visualization types (progress bar, bar graph, line graph, radial graph, and area graph) were tested. Test samples were designed for each of these.

In total, 146 participants were involved, divided into two groups (Group 1: 91 people; Group 2: 55 people). A convenience sample was used, and the respondents were students from six different universities in Croatia. The survey was shared by email, with different versions sent to students from different study years to ensure a more diverse sample. The results showed that visualization performance varied depending on the parameter being analyzed. Each parameter was first looked at on its own, and then together with the others.

Some parameters had a stronger influence on the overall impression than others. A regression model was created to show how key visualization parameters affect user experience. The results showed that attractiveness, usability and usefulness have an impact on the overall impression. Attractiveness has the strongest impact, meaning that the aesthetic and emotional appeal of the design is a key factor in shaping a positive impression. Usability and usefulness also contribute, but to a lesser extent. This suggests that while functionality matters, it's not as important as how the design looks and feels.

Interestingly, engagement didn't show a significant connection to user impressions, which means that simply making a visualization interactive doesn't automatically improve the experience. Parameters like readability, comprehension, and memorability had minimal influence, which may indicate that they matter less in comparison.

In conclusion, designers should prioritize attractiveness, usability and usefulness to maximize a positive user impression. While engagement and understandability are still relevant, they might need further refinement. The results show that the overall user impression is not random, but largely depends on specific design parameters and visualization execution. In other words, the quality of user experience can be predicted based on a combination of factors.

Guidelines for designing interactive mobile information visualizations were formulated based on these results. The

main contributions of this paper include a theoretical framework for evaluating mobile visualizations, empirical insights into the interrelations of user experience parameters, and design recommendations. Application of the guidelines will help designers create visualizations that are effective and usable for end-users.

Of course, there were some limitations to the study. The visualizations were tested as Figma prototypes, which don't offer the full functionality of real apps. Also, the participants were students, which limits how broadly the results can be applied to the general population. Another limitation was the unmoderated nature of the study. While this approach helps mimic a more natural user experience, it also makes it harder to control the test conditions. Additionally, screen size differences on mobile devices may have influenced how the visualizations were perceived and understood.

For future research, it is recommended to expand the sample to a wider population, test other visualization types, and different forms of interaction. In addition to that, it is recommended to examine the impact of visual variables (e.g. line thickness, element spacing, color, etc.) on the user experience. These visual design choices could lead to different perceptual outcomes. Overall, the results of this dissertation provide a deeper insight into the user experience of information visualizations in a mobile context and contribute to a broader scientific and professional discourse. The presented model and guidelines can serve as a tool for designers to make informed decisions during the design process, offering empirically based insights.

Keywords: design, information visualization, mobile apps, user experience, visualization design

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