Applied Computer Science, vol. 12, no. 4, pp. 96–110

Submitted: 2016-11-21
Revised: 2016-12-06
Accepted: 2016-12-15

user experience design, mobile website design, eye-tracking, case study

Magdalena BORYS[*], Monika CZWÓRNÓG[**], Tomasz RATAJCZYK[***]

WEB ANALYTICS COMBINED WITH EYE TRACKING FOR SUCCESSFUL USER EXPERIENCE DESIGN: A CASE STUDY

Abstract

The authors propose a new approach for the mobile user experience design process by means of web analytics and eye-tracking. The proposed method was applied to design the LUT mobile website. In the method, to create the mobile website design, data of various users and their behaviour were gathered and analysed using the web analytics tool. Next, based on the findings from web analytics, the mobile prototype for the website was created and validated in eye-tracking usability testing. The analysis of participants' behaviour during eye-tracking sessions allowed improvements of the prototype.

1. INTRODUCTION

The popularity of mobile devices provides new opportunities for website owners to reach users regardless of time or their location. However, creating a miniaturised version of the regular website is not a solution for mobile users. Mobile devices introduce new limitations, such as small screen sizes, wireless bandwidth or new interaction mechanisms based on gestures. The platform, user context, business context and technologies (Ballard, 2007) involved may differ as well. Therefore, creating a positive mobile user experience is an increasingly important and demanding task for website and application designers.

[*] Institute of Computer Science, Lublin University of Technology, Nadbystrzycka Street 36B, 20-618 Lublin, Poland, e-mail: m.borys@pollub.pl
[**] Institute of Computer Science, Lublin University of Technology, Nadbystrzycka Street 36B, 20-618 Lublin, Poland, e-mail: monika.m.czwornog@gmail.com
[***] Institute of Computer Science, Lublin University of Technology, Nadbystrzycka Street 36B, 20-618 Lublin, Poland, e-mail: kontakt@tomaszratajczyk.pl

The term *user experience* (UX) is defined as “a person's perceptions and responses that result from the use or anticipated use of a product, system or service” (ISO 9241-210, 2010). What is important, UX results not only from the system presentation, functionality, performance, interactive behaviour or assistive capabilities. It is also effected by the user’s former experiences, skills, preferences and even emotions.

Web analytics is the measurement and analysis of web site usage, whereby the complex interactions between web site user and web site can be better understood and optimized (Phippen et al., 2004). Therefore web analytics can lead to a significant improvement of the website user’s experience.

Eye-tracking is the process of measuring either the point of gaze or the motion of an eye. Eye-tracking can provide precise information about users’ interactions with any interface by determining either where the eye is focused or the motion of the eye on the interface.

User experience design (UXD) is a discipline aimed to fulfil the users’ needs and motives via product usage (Michailidou, Haid & Lindemann, 2015) by influencing their perceptions and behaviour (Unger & Chandler, 2012). The UXD process consists of five key phases: Strategy, Research, Analysis, Design and Production. At each of them designers use various sets of techniques to achieve a positive UX.

The paper presents an approach (as a set of techniques) ensuring a positive user experience for a mobile web design based on web analytics and eye-tracking techniques. The advantages of the method are a short research phase thanks to web analytics data collection and effective usability evaluation through the eye-tracking study used during the design phase.

The paper is organised as follows: Section 2, *State of the art*, presents the UX methods and techniques used to develop and evaluate mobile websites. A detailed description of the proposed approach for UXD is provided in Section 3, *A proposed method*. Section 4 presents a case study based on the proposed method for developing a mobile website for the Lublin University of Technology (LUT). The work discussed is summarised in the last section, *Conclusions*.

2. STATE OF THE ART

With the growing popularity of mobile devices, innovating methods and tools for mobile user experience (UX) research have been developed. The review focuses on UX research and evaluation methods like web analytics and user-based evaluation applied for mobile website design with an emphasis on educational institutions.

2.1. Web analytics in UXD

Beasley states that in UXD web analytics adds to or complements other UX methods. The most advised use of web analytics in UXD is to verify how well the findings from traditional methods on small group of users replicate on large populations of users, or to test the effectiveness of design changes (Beasley, 2013).

In his work, Bohyun Kim (2013) presents several studies in which university libraries surveyed thousands of patrons (with response rate of about 40%) to gather information about their attitude and expectations from a mobile library website. Moreover, some universities decided to form a focus group to better understand users' needs and carefully investigate the desirable features of a mobile library website. A contrary example of substituting paper-based and online surveys with web analytics to track behaviours of library website users and recognise their motivation is presented in (Fang & Crawford, 2008). The authors emphasise that web analytics in combination with the library system transaction logs helped to measure usability and redesign the existing website interface in a user-centred manner. Analogously, Loftus (Loftus, 2012) describes web analytics as a free and low-cost tool used for gathering data for a library website in an iterative design process.

A set of web analytics metrics useful for quick identification of usability problems with an e-commerce site is proposed by Hasan et al. (Hasan, Morris & Probets, 2009). Although such metrics can provide an overview of a site's usability or indicate a potential area of usability problems, to get more understanding of the issue, some other technique of usability evaluation is needed.

Another approach is proposed by Djamasbi et al. (Djamasbi et al., 2014). In their work, web analytics is used to measure the UX of an actual e-commerce website before and after it was optimised for mobile devices to verify the impact of the changes.

2.2. Mobile user experience evaluation

Diaz et al. in their works present the design process of a mobile educational website. Within the process, heuristic evaluation based on the W3C norms for mobile devices (Diaz, Harari & Amadeo, 2008b) as well as usability testing with users (Diaz, Harari & Amadeo, 2008a) were applied. As the authors declare, both methods were effective in identifying usability problems and gathering recommendations for a final redesign of the mobile interface.

An interesting study of the mobile websites of large research universities and their libraries is presented in (Aldrich, 2010). Based on expert evaluation of the mobile websites and apps of several universities and libraries, the author determined a set of features to provide more student-centric services on their mobile websites. Similarly, Liu & Briggs (2015) evaluated the current state of mobile websites among university libraries as well as their best practices through website inspection and survey questionnaires. Based on the results from Aldrich, Liu and Briggs' findings, the study of the level of adoption of mobile access to the academic libraries in the best universities, as well as the quality of services using expert evaluation, is presented in a paper by Torres-Pérez et al. (2016).

The heuristic evaluation of the mobile website of an Asian university is presented in Fung et al. (2016). The authors used Nielsen's ten usability heuristics to identify usability issues and the adequate improvements applied.

The eye-tracking technique, applied to UX evaluation, provides evidence of what attracts users' attention and what their preferences are of website content according to demographics (Djamasbi, Siegel & Tullis, 2010), how website complexity affects user's cognitive load (Wang et al., 2014) or how placement of web objects on different types of websites influences users (Roth et al., 2013). Eye-tracking applied to mobile interface evaluation can also reveal the preferred users' interaction strategy or interaction issues like improper sizing of a touchable element or inadequate gesture choice (Borys & Milosz, 2015).

The general assessment of the co-evolution of mobile UX methods and tools by considering requirements is presented in a paper by Nakhimovsky et al. (Nakhimovsky, Eckles & Riegelsberger, 2009). The comparative study of usability methods, including evaluation method for mobile applications, can be found in (Zaid, Jamaludin & Wafaa, 2012). An overview of user-based evaluation of mobile interfaces (Alshehri & Freeman, 2012; Coursaris & Kim, 2011), as well as heuristic evaluation (De Lima Salgado & Freire, 2014), is presented in these recent works.

3. A PROPOSED APPROACH

2.1. Methodology

The proposed approach for mobile website design follows the UXD process (Fig. 1). The strategy as well as production phases are beyond the scope of this work and will not be explained. The emphasis will be placed on the research, analysis and design phases.

The present approach is recommended for the development of a mobile website from an already accessible regular website. Additionally, web analytics data should be available a priori, therefore earlier installation of a web analytics tool is required.

Fig. 1. A proposed approach for mobile website design process (own study)

In the present approach, to gather information about users, web analytics is utilised. An advanced web analytics tool allows not only for acquisition of all the website users' data, it also provides options to choose specific segments of users (i.e. smartphones and tablet users) to analysis. Having once acquired the data, their analysis can be performed to better understand mobile users, their behaviours and needs. The results analysis provides mobile users' profiles and use cases (a form of system functional requirements). This allows to create an information structure and design an interactions mechanism for a mobile website.

When the information structure as well as interactions mechanism for a mobile website are recognised, the design phase could be started. This phase begins with the development of an interactive prototype. The more elements are implemented into the prototype, the more interactions can later be evaluated and adjusted. However, for a large website it is impossible to transfer all content or implement all functionality into the prototype. Therefore, the main attention should be placed into screens related to the use cases identified during the analysis.

Having the prototype, a user-based evaluation in the form of user testing can be conducted. To uncover more information about user behaviour, the user testing session should be supplemented with eye-tracking technology. The variety of eye-tracking devices allows for testing not only in laboratory environment, but also in users' natural environments or quasi-real conditions. The usage of the eye-tracking technique during user testing allows to integrate traditional usability metrics (related to user satisfaction, efficiency and effectiveness) with eye-tracking metrics (representing user visual attention, cognitive cost or load).

The analysis of user testing should not only identify usability issues, but also provide some insights for prototype improvement or final website design implementation. If a large number of significant usability problems are found, the user testing might be repeated. When the design phase is finished, the mobile website design can be finally implemented.

3.2. Advantages and shortcomings

The most important advantage of the present approach is the application of web analytics in order to gather information about users and then to analyse them. In particular, web analytics provides access to users' demographics, location and language settings, their technology, including device and screen information, operating system, browser, networks, activities (clicks, site searching, form filling), engagement, frequency of visits, and their acquisition channels.

Web analytics is a low-cost and time-effective method, besides installation process it does not require any additional effort. It gives access to a large population and thereby prevents indecorous respondent selection. What is more, web analytics not only provides data about the current state, it reveals the evolution of online trends and user behaviours. Finally, unlike other methods, web analytics provides objective data.

Another strength of the approach is integration of user testing with eye-tracking, which allows to better identify design issues in mobile design, taking into account its limitations. The insights gained about mobile users' visual attention and preferred ways of interaction lead to more effective and efficient interface design.

The major limitation of the method is the need to use an eye-tracking device, which is specialised equipment. However, on the market there can be found many low-cost eye-tracking devices that can be applied to visual-attention tracking.

The other shortcoming is connected with the user testing setup. Significant differences were found between usability tests on mobile phones conducted in laboratory and in a real life situation, including the frequency and severity of usability problems encountered, the users' behaviour, and subjective responses of users (Duh, Tan & Chen, 2006). Moreover, whether the usability testing is conducted on a mobile device or a desktop emulator, can influence testing results such as the mean task completion times and mean fixations per task (Levulis & Harris, 2015). Therefore, those implications should be taken into account during planning user testing experimentation.

4. A CASE STUDY: THE LUT MOBILE WEBSITE

Everyday more than 5 thousand users visit the Lublin University of Technology (LUT) website and about 20% of them use smartphones and tablets. Nevertheless, the LUT website is not responsive or does not have its mobile version to meet the needs of those mobile users.

4.1. Web analytics in work

Firstly, to understand mobile website usage and behaviour patterns, a large set of web analytics data were utilised. Web analytics led to the identification of mobile user groups, their tasks and the context in which they perform them.

In recent years, a significant increase in the use of the Lublin University of Technology website by using smartphones and tablets were noted. For the period from 20.05.2011 to 20.05.2015 the total number of sessions visited by all devices is 6 488 982, including mobile phones 335 689 (5.17%) and tablets 55,445 (0.85%). Detailed information about how mobile device usage changed over time is presented for the periods of 20.05.2011 to 20.05.2012 and 20.05.2014 to 20.05.2015. In the first period, mobile devices reached 1.05% of total traffic, while in the second there was a significant increase in this value to 10.45%. Similarly, the number of visits from tablets increased, but on a smaller scale – from 0.03% in 2011/2012 to 1.36% in the period 2014/2015.

Recommended resolution for smartphones are: 360x640px, 320x534px, 480x800px and 320x480px. In the case of tablets, these values are: 768x1024px and 1280x800px. Currently, in the case of mobile devices, Google Chrome leads with a value of 50.79% of all visits. In the next position is a native browser of Android devices with a value of 21.55%, third place in the ranking is the browser iOS Safari with a score of 12.07%. Two most popular operating systems on mobile devices are Google Android and Apple iOS. Current data indicate a significant advantage of the operating system of Google – Android has 81.34% of visits from mobile phones, the next position is occupied by Apple's iOS with a value of 8.05%, in the third place is Windows Phone (7.28%). 1.06% of the devices were not recognised by the operating system. The percentage distribution of the operating systems used on tablets are: Google Android (54.73%), Apple iOS (36.88%), Windows (7.86%), and Firefox OS (0.52%).

The most interesting pages for most visitors are: information for candidates (6.85%), time-tables (5.22%), and information from the student career centre (3.51%). The remaining percentage of visits is less than 2%. In the case of mobile devices, time-tables are at the first position with 9.23% of all visits, followed by information addressed to students on the subpage */pl/studenci* with a score of 8.63% (for desktop devices it was only 1.88%), the third place is occupied by subpages for candidates with a score of 8.18%.

In order to broaden the information on the pages visited by users, it was decided to use Google Analytics "*In-Page analytics*", showing the number of clicks for a given area of the page in a given period of time.

Moreover, the Lublin University of Technology webpage has been checked for usability and user experience by using the "*Mobile-Friendly Test*" tool. The analysis shows that the LUT website is unsuitable for use on mobile devices. The main reasons of this assessment are: small font, which makes it difficult to read the text, links to other pages located too close to each other and the lack of settings connected with working for a portable device – for smaller screen sizes, the page is displayed on half of the screen of the mobile device, the remaining area is undeveloped (Fig. 2).

Analysis lead to the conclusion that the main functions of the website are:

1. checking the student time-tables;
2. searching for an internship or job opportunities;
3. obtaining information about the recruitment process and studies profiles;
4. obtaining information about scholarships, grants, exam results and university announcements;
5. searching for LUT employee contact information using the address book.

The group that use the Lublin University of Technology website and for which a profile was developed are: students, candidates, LUT employees, LUT graduates and others (including entities cooperating with the university like media, companies or institutions).

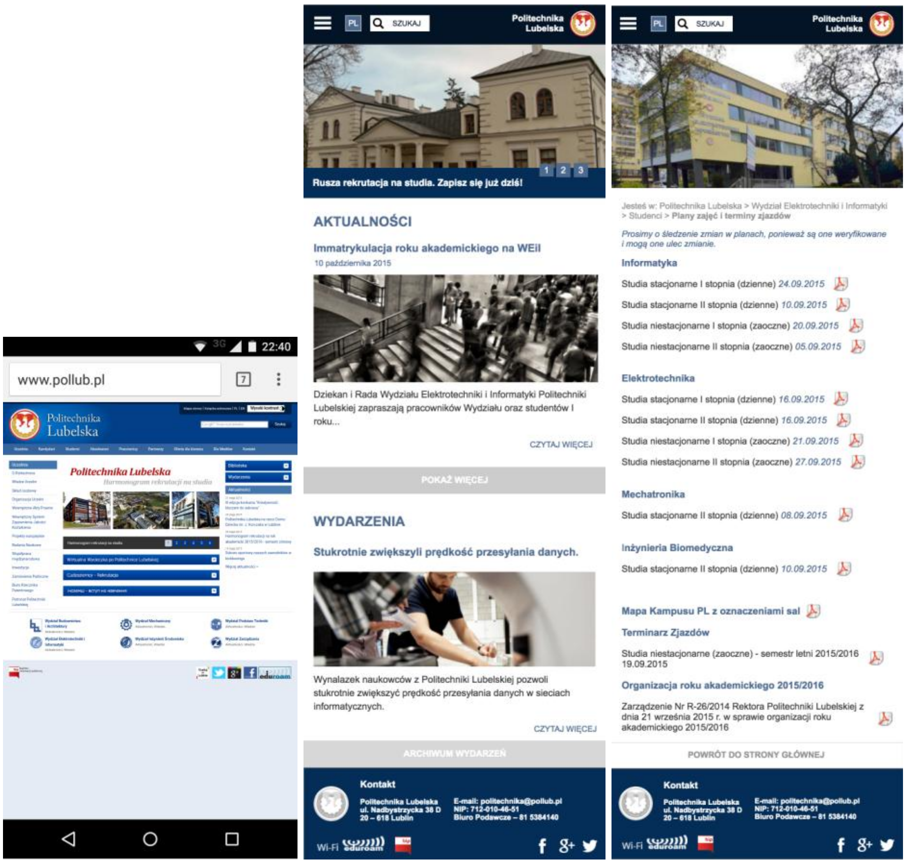

Fig. 2. From the left: homepage of the LUT website displayed in a mobile device, prototype of the LUT mobile website homepage, prototype of the time-tables for the Faculty of Electrical Engineering and Computer Science (own study)

4.2. Prototyping mobile web design

The prototype was created by the prototyping tool Axure RP Pro. The program allows to design a fully interactive mock-up, which simulates normal website interactions.

The design process began with rebuilding the information structure based on previous experience and information gathered from user groups. The real website content was placed into the mobile prototype.

One of the most important components present in the mobile website design is a search engine (Fig. 2). It was deliberately placed at the top of the page, for everyone to quickly find it and search for the desired phrase.

Another component, equally important, but slightly different from the desktop version, is the menu available at the top of the page in the form of a "*hamburger menu*". It consists of 8 categories, 7 of which being drop-down ones.

On the main page, other elements were placed below the slider in the form of articles, directly accessible by clicking on them. In order to facilitate the navigation, the whole article area (titles as well as graphics) link to the article webpage.

The last element on the website is a footer, which was divided into several smaller sections. There is contact information, such as the university's address, contact number and navigation elements to selected university services and social media.

As shown in Figure 2, other webpages also include those main components. Additionally, just before the footer, the return button to the university homepage was placed to allow quick navigation.

4.3. User testing with eye-tracking

To verify and optimise the mobile design, usability testing with eye-tracking was performed. It took place in the Laboratory of Movement Analysis and Interface Ergonomics at the Lublin University of Technology.

A total of 10 participants with 20/20 vision or corrected-to-normal vision took part in this study. Two of the participants had never used the Lublin University of Technology website, while others had used it at least once. Each person was tested in the same way, in the same experimental conditions.

Tobii TX300 Eye Tracker (video-based eye tracker, Tobii Technology AB, Sweden) supplied with a 23" TFT monitor was used to acquire eye-position data at a sampling rate of 300 Hz. Gaze data were recorded from both eyes.

The experiment was created using Tobii Studio 3.2. The mobile website prototype was displayed by the Microsoft IE browser. Participants were seated while working with the prototype. The distance between the screen and the subject was in a range of 50 to 80 cm.

The eye tracker was calibrated using a 9-point built-in calibration procedure at the beginning of each session. Once calibrated, the participants were provided with the experimental instructions on the screen.

The participants were asked to complete the following tasks using the prototype of the mobile website during the session:

A. As a candidate for engineering studies in Computer Science at the Faculty of Electrical Engineering and Computer Science:
   1. find the subjects that should be taken during the matriculation examination to ensure enrolment for the studies,

2. verify how to calculate points in the recruitment procedure,
3. check how to apply for a place in a student dormitory.

B. As a student of the fourth semester in Computer Science at the Faculty of Electrical Engineering and Computer Science:
4. find the timetable and the date of its last update,
5. check the official document on the organisation of the academic year,
6. find an offer for an internship for a programmer for the duration of the winter holidays.

After performing the tasks, participants were asked to complete the questionnaire. It consisted of questions about the participants' satisfaction level in each task, as well as an open question concerning the interface.

In the analysis of the mobile website prototype, the usability metrics and eye-tracking measures were combined. The visualisations of the eye-tracking metrics, such as scanpaths and heat maps, were created by using Tobii Studio 3.2.

The following usability metrics were used in the analysis:

– Task Level Satisfaction (TLS). The user's subjective assessment of how difficult the task was. It measures comfort and acceptability (satisfaction metric). The Likert scale from 1 (very difficult) to 10 (very easy) was used.
– Completion Rates (CR). The completion rate is calculated by assigning binary values: 1 = Task success and 0 = Task failure (effectiveness metric).
– Task Time (TT). Total task duration measures of efficiency and productivity (efficiency metric).
– Error Rate (ER). The number of any unintended actions, mistakes or omissions all users make while attempting a task (effectiveness metric).
– Number of Interactions (NoI). The number of any interactions made by the user to complete a task (efficiency metric).
– Scrolling Rate (SR). Binary value representing if the user did scrolling interactions to complete a task (efficiency metric).
– Page Views (PV). Total number of user views of a webpage to complete a task (efficiency metric).

The following eye-tracking metrics were used in the analysis:

– Number of Fixations (NoF). The number of fixations, assumed to be negatively correlated with search efficiency.
– Mean Fixation Duration (MFD). Fixation duration indicates the workload of a task. Longer fixations reveal increase in cognitive processing loads.
– Time to First Fixation (TFF). The time to first fixation indicates the amount of time that it takes a user to look at a specific AOI. In this case the "hamburger menu" was selected as the area of interest.

The calculated usability metrics for user testing are presented in Table 1. TLS, TT, NoI and PV are calculated as average values among all participants, ER is presented as a sum of errors all participants made, CR and SR are presented as the percentage of users who completed a task or used the scroll during the process. The calculated eye-tracking metrics as average value among all participants are presented in Table 2.

As presented in Table 1, all participants completed the tasks in less than 1.5 minutes each. It can be noticed that TSL is influenced by NoI performed and correlated with its number of errors performed (more errors cause more user interactions). Those additional interactions are caused by menu arrangements (created information structure). The information structure depth assessed as very satisfied by the participants was 3, which is reflected in PV and NoI.

Tab. 1. Usability metrics (own study)

	TLS	**CR**	**TT**	**ER**	**NoI**	**SR**	**PV**
Candidate							
Task 1	6.9	100%	94s	18	17.2	100%	3.5
Task 2	8	100%	22.86s	0	6,4	100%	3
Task 3	6.7	100%	73,9s	13	12.6	100%	3.3
Student							
Task 4	9	100%	39.2s	1	7.2	40%	3
Task 5	8	100%	59s	1	10	100%	3.5
Task 6	6.9	100%	61s	10	14.6	100%	4

Tab. 2. Eye-tracking metrics (own study)

	NoF	**MFD**	**TFF**
Candidate			
Task 1	235.8	0.29	20s
Task 2	58.8	0.34	7.3s
Task 3	200	0.30	16.5s
Student			
Task 4	112	0.31s	4.5s
Task 5	153	0.34s	4.6
Task 6	199	0.30s	3.4

The large NoF as well as long TFF presented in Table 2 for Task 1 (candidate role) can be explained by the first interaction of participants with the interface. Therefore, they spent an adequate amount of time to explore freely all the interface elements. This is also the reason that in this task the cognitive load expressed in MFD is the smallest among all the values in the study.

The navigation path to information searched in Task 2 and Task 4 is well arranged, as evidenced by NoF (small NoF). However, the placement of information for Tasks 3 and 6 should be redesigned, because in those tasks participants revealed ineffective search actions (large NoF).

The scanpath (a sequence of fixations) can indicate the efficiency of the arrangement of elements in the user interface. As presented on Figure 3, for the first few sections of their interaction with the homepage participants explored the top menu ("hamburger menu") with its options. When they viewed other webpages, like time-tables or studies information webpages, their gaze was more distributed on the webpage content.

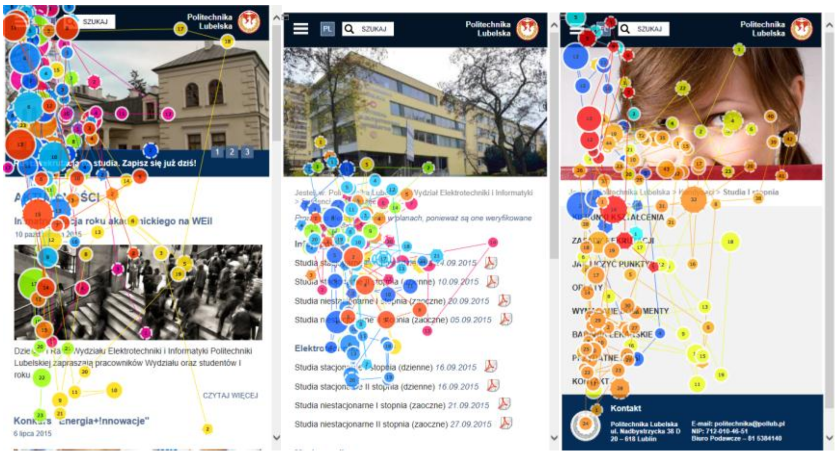

Fig. 3. Scanpaths for the homepage, the timetables webpage and the information about Engineering studies page, with duration limited to the first 10s (own study)

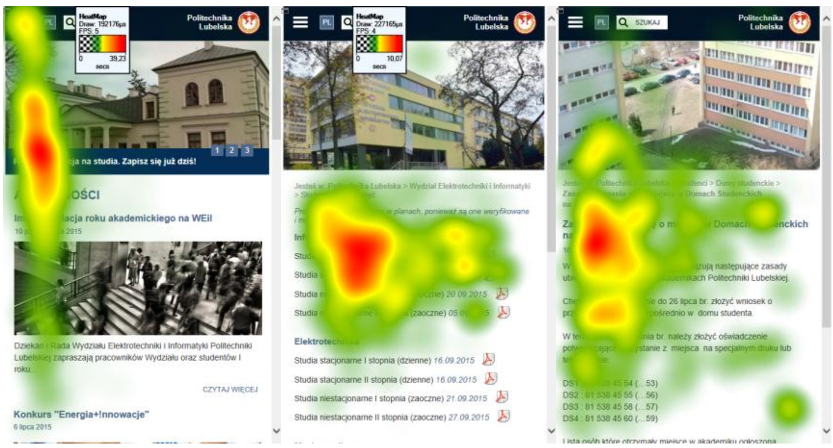

Fig. 4. Heat map for homepage, time-tables webpage and dormitory placement page (own study)

Heat maps show the general distribution of fixations. Such maps were generated for the homepage, time-tables webpage and dormitory placements page (Fig. 3). Heat maps for the latter two webpages prove that participants omit the image presented below the menu and read the content presented below. This demonstrates that the image has only a decorative purpose: it does not provide any information to the users and force them to scroll to reach the full content, therefore it should be removed.

4.4. Mobile website redesign

Finally, the analysis of usability metrics and eye-tracking measures enabled the prototype improvement – the final version of the LUT mobile website design.

These changes are related mainly to the structure of the menu – the location of the sub-category, reorganising the content placed on the webpages, or redundant links to specific pages.

Menu improvements involved removing submenu items that did not provide clear information (such as: "*Must have for future student*" or "*Information about the studies*" from the submenu *Candidates*). These items described general information about studying in the form of PDF files, updated occasionally, which interrupt the user's natural flow of on the website.

Such redundancy links lead to more effective navigation paths for the most frequent tasks. For example a new menu item in the *Candidates* submenu called *Dormitory* was added, although it was already present in the *Students* submenu, because a majority of respondents searched for information on dormitories there. The submenu *Students* has been moved to the top of the menu to make the *Schedules* webpage faster accessible.

The path followed by participants during their search for jobs on vacation often affects the "IT industry" links in the Careers Office, because – as suggested by the current desktop version – there may be information about work or internships in the IT industry.

Moreover, the decorative image placed below the top menu on webpages other than the homepage was removed. Users did not pay attention to the image, but it caused the page-scrolling action aimed at getting to the main content.

5. CONCLUSIONS

The proposed approach for mobile website design follows the UXD process, however the main focus is placed on the research, analysis and design phases. The approach is recommended for development of mobile websites from already accessible regular websites, and installed web analytics for data acquisition.

The most important advantage of the present approach is the application of web analytics to gather and analyse information about users, because web analytics is a low-cost and time-effective method. The other strength of the approach is integration of user testing with eye-tracking, which allows to better identify design issues in mobile design. The limitations of the method are the need of using an eye-tracking device, which can be costly depending on equipment/model/version/... selection, and some differences in user performance between different testing setups, especially in laboratory environment.

However, as was hopefully demonstrated in this case study, the approach allows for efficient and effective interface designing for a valuable mobile user experience.

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