

Need for Usability and Wish for Mobility: Case Study of Client End Applications for Primary Healthcare Providers in Croatia

Mihael Kukec¹, Sandi Ljubic², and Vlado Glavinic³

¹ Polytechnic of Varazdin,
Jurja Krizanica 33, HR-42000 Varazdin, Croatia
mihael.kukec@velv.hr

² Faculty of Engineering, University of Rijeka,
Vukovarska 58, HR-51000 Rijeka, Croatia
sandi.ljubic@riteh.hr

³ Faculty of Electrical Engineering and Computing, University of Zagreb,
Unska 3, HR-10000 Zagreb, Croatia
vlado.glavinic@fer.hr

Abstract. In the Croatian e-Health system, client end applications for primary healthcare providers must undergo the process of official approval. This process is based on verifying both content and format of messages used in client software for data exchange with the central part of the integral information system. However, there are no formal specifications, nor design guidelines concerning usability and overall user experience. In this paper, we reveal a number of UI usability issues in existing client applications that represent the source of enlarged interaction burden and user displeasure when working with client software. Furthermore, we propose a UI lightweight prototype model, based on both conducted investigation and well known usability guidelines, adding the value of its potentiality for usage in the mobile domain. End users supported our model design, by emphasizing its simplicity and better usability, as well as by showing eagerness for prototype implementation for mobile devices such as smartphones and/or tablets.

Keywords: e-health applications, usability, mobile applications

1 Introduction

Rapid development of the communication-information infrastructure, along with the need for health record data exchange in both horizontal and vertical organizational direction, has made it possible to introduce new initiatives for the integrated health information systems. In the Republic of Croatia, the first comprehensive initiative related to such project implementation involved primary healthcare (PHC) offices only (dispensaries of general practitioners, pediatricians, and gynecologists). As a result, the first version of the Croatian Primary Healthcare Information System (PHCIS) was developed, incorporating specifications and widely accepted standards

for medical data logging, exchanging and securing, in a form of Electronic Health Records – EHRs [1, 2, 3]. This project represents the beginning of the era of applying e-health concepts in Croatian health data management.

Introducing e-health concepts is an ongoing procedure, with many business entities and partners gradually integrating into central system. Currently, alongside PHC practitioners and nurses, relevant applications are actively used within parties such as the National Health Insurance Company (HZZO) and the Public Health Institution (HZJZ), while pharmacies (e-prescriptions) and laboratories (e-ordering) represent recent and upcoming objectives (Figure 1).

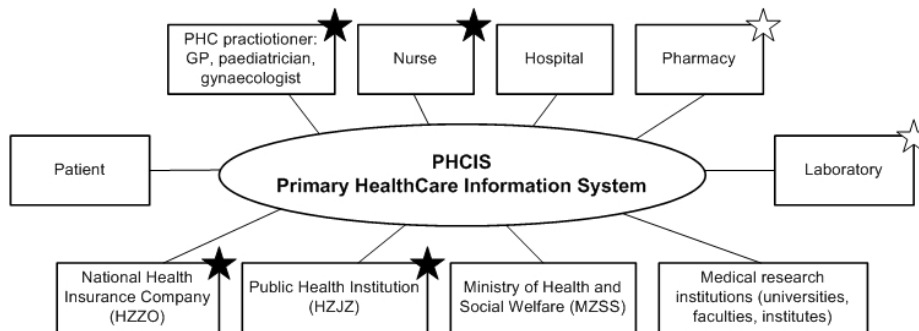


Fig. 1. Overview of possible users (business entities and partners) within the PHCIS system in the Republic of Croatia. Full stars represent entities involved in the first phase of system integration, while hollow ones represent units that are currently being introduced.

Figure 2 shows the PHCIS basic component and communication layout. The complete solution consists of the G1 system (PHCIS central part, including the PHC portal, the message management system and the relative registries), (a number of) G2 applications (which are the software for PHC practitioners), and the HL7v3 [4] international standard for medical data format and message exchange protocol. The company *Ericsson – Nikola Tesla* (ETK) was awarded the G1 component realization, while the implementation of G2 software(s) was offered to independent software providers on the Croatian market. In order to ease the implementation efforts of the autonomous providers, and to ensure HL7v3 compatibility, ETK released a special software interface for communication with the G1 infrastructure.

G2 applications (client-end applications for primary healthcare providers) must undergo the process of certification, where the final approval is granted by the Croatian Ministry of Health and Social Welfare (MZSS). Certification criteria are focused on several issues, such as: (i) appropriate data structures associated to Reference Information Model (RIM) of the HL7 standard, (ii) suitable communication requirements for private data security, (iii) adequate XML messages format for data exchange, according to the relevant HL7-based XML schema, and (iv) satisfactory programming form and task flow adjusted with typical usage in medical domain [5, 6].

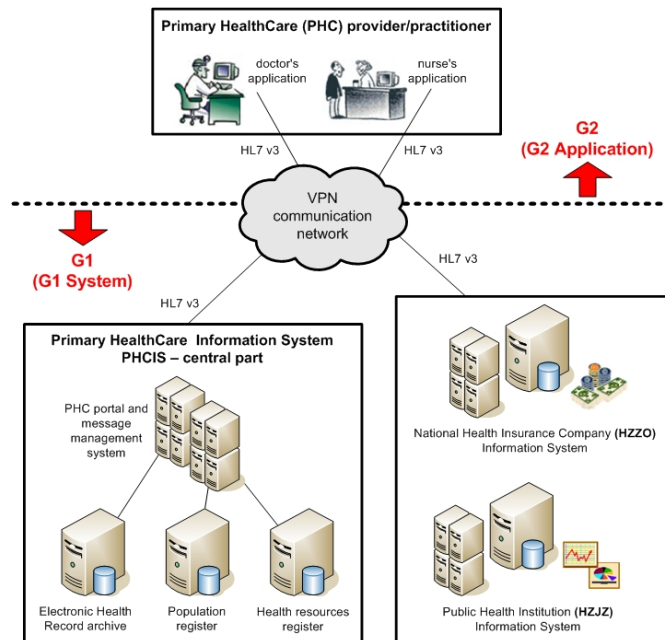


Fig. 2. Primary HealthCare Information System: the complete solution consists of the G1 system, a number of G2 applications, and the HL7v3 standard defining both data formats and the message exchange protocol.

However, there are no formal specifications, nor design guidelines concerning usability and overall user experience for G2 client end applications. Ergonomic factors, user interface design, interaction design, and usability in general are not encompassed by the certification procedure. This represents a big shortcoming in the overall process of e-health introduction, as end users are often left struggling with inconsistent interfaces and bad interaction designs.

Moreover, the current system is obviously undersupplied with respect to a suitable mobile context support. Although nowadays mobile technology upgrowth promises the introduction of a variety of mobile services, actual e-health system specifications are not dealing with the possibilities of involving m-health activities. As personal mobile devices are becoming more pervasive and more powerful application platforms, it could be very useful and valuable to use them in particular primary healthcare procedures. A typical example of such a procedure is the doctor's home visit to a patient. Usually in such kind of context, every action in the characteristic task flow (opening patient's record, diagnosis recording, treatment and/or medication prescribing) is performed via paperwork, thus subsequently requiring the doctor to carry out some data synchronization with the software application (generally done by retyping some manual annotations). In such cases, appropriate mobile applications for smartphone and/or tablet devices, with data auto-synchronization feature, would be a great time-saver tool for efficiency enhancement. Certainly, the mobile application UI, as well as the overall mobile interaction design, should be implemented according

the general principles of good usability and taking into consideration typical mobile device limitations.

In the following sections, we will highlight a number of UI usability issues in a typical client (G2) application that represent the source of enlarged interaction burden and user displeasure for the user. Alongside usability evaluation and analysis of such an application, we propose a lightweight prototype model of a mobile UI for a doctor's home visits (mobile) application.

2 Usability Issues in a G2 Application: Heuristic Evaluation

Usability is a term that collectively describes multiple components of user contentment in the course of interaction with the interface of computer software. A well known definition of usability by Nielsen explains usability as a multidimensional property of a user interface comprising the following five generally accepted attributes: (i) *learnability*, (ii) *efficiency*, (iii) *memorability*, (iv) *errors*, and (v) *satisfaction* [7]. A system that is "acceptable and easy to use for a particular class of users carrying out specific task in a specific environment" [8] should be very easy to learn, with a very steep learning curve (*learnability*), thus enabling the user to start producing results with the system in the earliest moment possible. Acquired knowledge of UI metaphors, symbols, and expected action results should be easy to recall after some period of time without the need to repeat the learning process (*memorability*). After the initial learning process has ended, the user must be able to achieve a high level of productivity (*efficiency*) and low error rate in the course of interaction with the system using the UI. If errors are made, the system must enable an easy recovery (*errors*). Overall, the system should give the user the impression of subjective *satisfaction*.

To ensure that a software project has an appropriate level of these essential usability characteristics, we can use methods that can be divided into two general groups: inspection methods (involving expert users) and test methods (involving test users in carefully prepared experiments) [8]. Following the concept of discount usability assessment [9, 10], we decided to perform a heuristic evaluation of a typical G2 application, including both domain experts (doctors and nurses that use this application on a regular basis) and usability/HCI experts. In this way, we intended to achieve a synergetic effect of multidimensional insight into existing usability issues within application representative use cases.

Final results of a heuristic evaluation always depend on a few experts' judgment of the application/system compliance with a particular set of generally formulated design guidelines (heuristics) in the specific context of use. Conclusions are therefore determined according to evaluators' experience and intuition. However, there is no unique consensus on general usability guidelines, resulting in many different sets of recommendations for designing systems with high level of usability. Consequently, a heuristic usability evaluation can be based on various well-known design principles, e.g. Hansen's (*principles for the design of interactive graphics systems*) [11], Shneiderman's (*eight golden rules of interface design*) [12], Nielsen's (*ten usability heuristics*) [13], Polson and Lewis' (*design for successful guessing*) [14], Gould's

(four principles of system design) [15] or Norman's (seven principles for transforming difficult tasks into simple ones) [16]. Each one of these principle sets deals with particular characteristics of the target system/application (see Table 1).

Table 1. Well known design/usability heuristics and application/system characteristics that are covered by corresponding sets of principles

Application/system characteristic	Principle set (heuristics)					
	Hansen	Shneiderman	Nielsen	Polson & Lewis	Gould	Norman
Consistency	✓	✓	✓		✓	✓
Presentation convenience		✓	✓	✓	✓	✓
Error handling	✓	✓	✓	✓	✓	✓
Memory load reduction	✓	✓	✓		✓	✓
Task adequacy			✓	✓		✓
Shortcuts/accelerators		✓	✓			
Back way redirection		✓	✓		✓	
Help			✓		✓	

We decided to use Nielsen's usability heuristics, as it covers all of the significant aspects of application UI usability. The corresponding set of principles represents general guidelines for UI design, and thus can, without any restriction, be applied as an evaluation base for e-health application software.

As for the number of evaluators included in the application analysis, we used a relatively small set of experts (end users). According to [17], no less than 85% of all usability problems can be detected with only 5 users, while more recent research denote "10±2" as a general rule for the number of people required in a usability evaluation [18]. Therefore in our case, a total of 8 evaluators were included in the application inspection procedure, 5 of them being domain experts (familiar with medical terminology and usual primary healthcare datasets) and 3 of them being HCI professionals (with thorough understanding of usability matters). The latter were introduced with some basic task flow in the primary healthcare practice.

Evaluators were asked to fulfill several typical tasks via the application UI that correspond to real use cases: opening a health record database, finding the record for a particular patient, logging (writing) the examination outcomes - diagnosis, prescribing a medication, and ordering a laboratory test. Unlike domain professionals (doctors and nurses), usability experts are explicitly told to do some additional explanatory UI inspection. Upon completion of the application tasks, all users were presented with a heuristic evaluation questionnaire, containing altogether 17 questions derived from Nielsen's usability guidelines (Table 2). Discrete values (from 1 to 5) were expected as assigned answers on the semantic differential scale. In order to insure consistency throughout the questionnaire, each question started with same prefix ("In what extent..."). There was no time limit to complete the survey, but all evaluators managed to finish it within 30 minutes.

Table 2. Nielsen's ten usability heuristics - general principles for user interface design (H1-H10) along with questions for the evaluation survey (Q1-Q17) derived therefrom.

H1 - Visibility of system status	The system should always keep users informed about what is going on, through appropriate feedback within reasonable time.
Q1: In what extent the user feels to have full control over the application behavior?	
H2 - Match between system and the real world	The system should speak the users' language, with words, phrases and concepts familiar to the user, rather than system-oriented terms. Follow real-world conventions, making information appear in a natural and logical order.
Q2: In what extent the user can understand phrases and messages shown within application interface?	
Q3: In what extent the used terminology is more computer-oriented than medicine-oriented?	
H3 - User control and freedom	Users often choose system functions by mistake and will need a clearly marked "emergency exit" to leave the unwanted state without having to go through an extended dialogue. Support undo and redo.
Q4: In what extent the user can easily (i.e. in a consistent way, and without unexpected consequences) abort the current activity through UI dialogues?	
Q5: In what extent the user can be redirected without trouble to a former abort point?	
H4 - Consistency and standards	Users should not have to wonder whether different words, situations, or actions mean the same thing. Follow platform conventions.
Q6: In what extent the application interface contains different terms and phrases for the same concept?	
Q7: In what extent the different application actions result with the same outcome?	
H5 - Error prevention	Even better than good error messages is a careful design which prevents a problem from occurring in the first place. Either eliminate error-prone conditions or check for them and present users with a confirmation option before they commit to the action.
Q8: In what extent the application help system supports the user by both indicating possible errors and trying to resolve them?	
Q9: In what extent the application can help the user to follow well-known procedures in primary healthcare tasks, without introducing unexpected errors?	
H6 - Recognition rather than recall	Minimize the user's memory load by making objects, actions, and options visible. The user should not have to remember information from one part of the dialogue to another. Instructions for use of the system should be visible or easily retrievable whenever appropriate.
Q10: In what extent the user has to temporarily stop and (re)consider the UI action/control to be activated?	
Q11: In what extent the application provides additional relevant information about the meaning of a particular UI element (e.g. through tooltip use)?	
H7 - Flexibility and efficiency of use	Accelerators -- unseen by the novice user -- may often speed up the interaction for the expert user such that the system can cater to both inexperienced and experienced users. Allow users to tailor frequent actions.
Q12: In what extent the user can use interface shortcuts (accelerator keys, automatic procedures) for frequently performed actions?	
H8 - Aesthetic and minimalist design	Dialogues should not contain information which is irrelevant or rarely needed. Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility.
Q13: In what extent the user interface increases visual complexity by imposing rarely required and irrelevant controls?	
H9 - Help users recognize, diagnose, and recover from errors	Error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution.
Q14: In what extent the user can understand the real meaning of the error messages?	
Q15: In what extent UI actions can result with unexpected outcomes with no error/warning messages?	
H10 - Help and documentation	Even though it is better if the system can be used without documentation, it may be necessary to provide help and documentation. Any such information should be easy to search, focused on the user's task, list concrete steps to be carried out, and not be too large.
Q16: In what extent the application can be used without any help (sub)system and/or user manuals?	
Q17: In what extent the user can easily find task-oriented information within available manuals and/or help system?	

Results thus obtained are shown in Table 3, where the last column marks questions whose answers indicate a higher discrepancy from "good usability". In general, we can infer that application usability is considered rather low, with distinguished flaws in the area of aesthetic and minimalist design, user control and freedom, flexibility and efficiency of use, metaphors, and help and documentation.

Table 3. Results of usability heuristics evaluation survey. Examinees 6, 7 and 8 are the HCI/usability experts, hence the extent of their overall application usage is not relevant. Up-arrows denote records where a higher value indicates better compliance to the usability guideline. On the other hand, down-arrows indicate that a lower value conforms better to the particular principle.

Examinee	1	2	3	4	5	6	7	8		
Age	45	29	44	35	58	41	31	33	AVG = 39,50	
Time period of overall application usage (months)	11	18	31	30	28	-	-	-	AVG = 23,60	
Gender	F	F	F	F	M	F	M	M		
Question	Individual answers								AVG	↑↓
Q1	2	4	3	4	3	3	2	3	3,00	↑
Q2	3	4	3	4	4	4	3	4	3,63	↑
Q3	3	3	4	5	5	4	5	3	4,00	↓ * *
Q4	2	2	3	2	3	2	2	1	2,13	↑ * *
Q5	3	2	4	2	3	2	2	2	2,50	↑ * *
Q6	2	3	4	3	2	2	3	2	2,63	↓
Q7	1	2	2	2	1	2	2	3	1,88	↓
Q8	3	3	3	2	3	4	5	4	3,38	↑
Q9	2	3	2	3	3	3	4	4	3,00	↑
Q10	3	3	3	3	3	3	4	3	3,13	↓
Q11	1	2	2	2	2	2	3	2	2,00	↑ * *
Q12	2	2	3	3	2	1	2	1	2,00	↑ * *
Q13	3	2	1	2	3	1	2	1	1,89	↑ * *
Q14	3	3	3	2	4	3	2	3	2,88	↑
Q15	3	3	4	2	3	3	4	2	3,00	↓
Q16	2	3	2	2	3	2	2	2	2,25	↑ * *
Q17	2	2	3	3	2	2	2	2	2,25	↑ * *

Informal conversations with application end users (carried out after the evaluation) revealed general displeasure with the respective UI. While domain experts emphasized "fuzziness" in the UI layout, along with overwhelming window dialogues (especially at the beginning of the application usage), HCI experts were able to strictly point out some examples of bad design. In the next section, these application issues are explained in more detail, highlighting the main causes of poor usability as exposed by heuristic evaluation results.

3 Usability Issues in a G2 Application: Problem Analysis

In the evaluated application we can assume that problems related with usability are mainly inherited from the implementation approach. Since the G2 application certification process is primarily focused on data format (and data exchange) compliance, most of the UI dialog layouts appear like auto-generated entry forms and/or reports extracted from programmed dataset structures. Some UI elements (visual controls) even look identically to those used in database management systems. Obviously, such a data-driven approach (which binds complete datasets to a large number of UI controls) outweighs user-centered design principles if any at all were used. In such circumstances, there exists a considerable possibility for introduction of severe usability problems.

Regarding aesthetic and minimalist design (H8 – Q13), the related usability guidelines are consistently violated throughout the majority of UI dialogues. The example illustrated in Fig. 3 shows a UI dialogue snapshot within the process of generating medication prescription. A large number of very rarely used controls (labels, textboxes, and combo boxes) is always imaged on the screen, unnecessarily increasing the UI visual complexity. Domain experts claim that these controls are used in no more than 5% of all use cases. The related usability issue can easily be avoided by simple hiding the control set, and exposing only one "activate command" (e.g. a button) for displaying rarely used forms. Also, using the separate tab control for infrequently used fields would be an appropriate solution in this case.

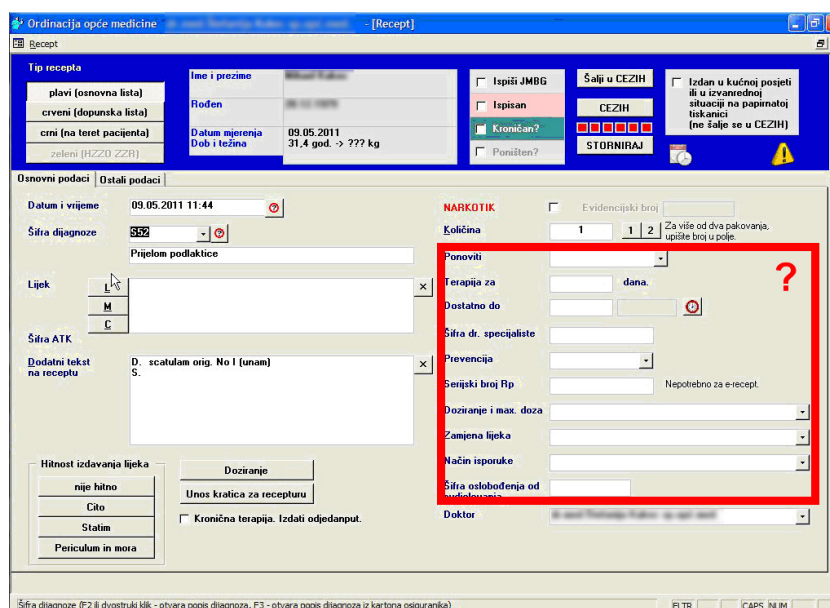


Fig. 3. Violation of aesthetic and minimalist design guidelines: snapshot of application UI dialogue for generating medication prescription.

When it comes to user control and freedom (H3 – Q4, Q5), the application sometimes holds an inconsequent way of using the "exit" command. In general, the "emergency exit" should be used for leaving an unwanted state, and should additionally be clearly marked. However, Fig. 4 presents the case when the user has to confirm (save) the changes she/he made in the dialogue form, by explicitly calling the "exit" command. Absence of some kind of "save button" is unclear enough, but having to call from the context menu (otherwise not visible on the screen until an explicit mouse right-click) the "exit" command for saving changes furthermore spoils the situation. Such a procedure for an otherwise simple task is very confusing, leaving the user with a sense of loosing control over the application behavior. This especially holds when it comes to UI consistency since other dialogues use "exit" as a well-known action, without implicitly saving user data.

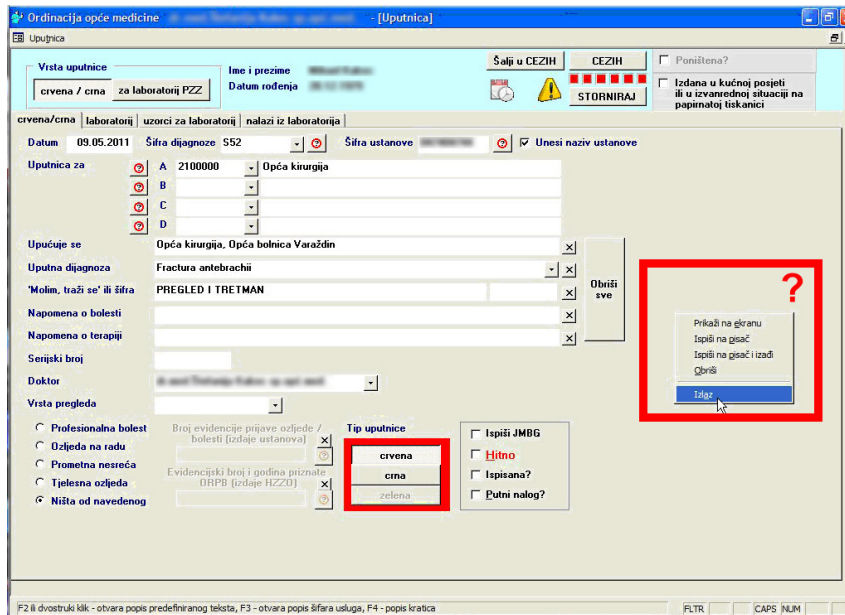


Fig. 4. Violation of user control and freedom guidelines: inconsequent use of the context menu "exit" command for input confirmation. This application snapshot shows the use case of ordering a patient for specialist treatment.

Concerning flexibility and efficiency of use (H7 – Q12), the application UI is lacking any shortcut commands. There exist no embedded procedures for distinguishing experienced and inexperienced users' interaction patterns. As a result, a more proficient user has no possibility to speed up the dialogue flow, nor she/he can customize any part of the user interface. A typical example where valuable efficiency enhancements could be obtained is shown in Fig. 5. Very often the user is required to browse for a distinct item within extremely large drop-down lists and/or combo-boxes. This is regularly related to with searching through various medical registries (primary healthcare service types, diagnosis descriptions, medication codes etc.). Related tasks are time-consuming, as the user is distracted by a complete set of

numerous options. For this purpose, involving algorithms for automatic menu personalization would be a great choice. Using both frequency-based and recency-based adaptive approaches, a user's prior navigation behavior can be taken into account, thus resulting with optimal items arrangement within large lists [19]. In this way, each individual user could easily find and activate her/his commonly used selections and could become much more efficient in comparison with currently implemented solutions.

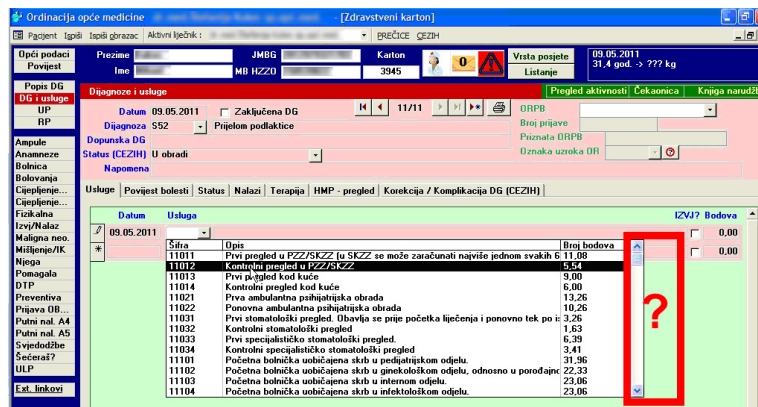


Fig. 5. Violation of flexibility and efficiency of use guidelines: there is no possibility (at all) for UI customization and/or adaptation. This snapshot presents the selection of primary healthcare service type provided to the patient.

Poor icon metaphors represent another application limitation in the terms of usability, where a number of principles is undermined (H2 – Q3, H6 – Q11). Since clear communication between the application and end user is critical to usability, the user needs to be able to immediately know what the icon represents. However, this is not the case in the example presented on Fig. 6.

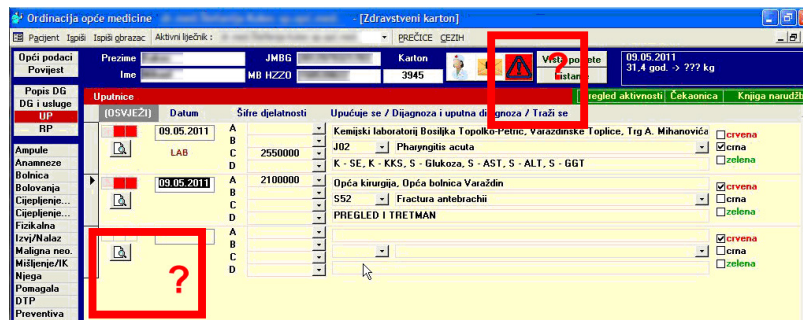


Fig. 6. Examples of poor icon metaphors and insufficient emphasis of significant information. The snapshot shows the use case of referring a patient to laboratory testing.

Although the magnifier icon usually stands for searching and/or zooming (at least in the majority of modern software interfaces), within the tested application it is unexpectedly used for starting a new record entry (in the process of referring the patient to laboratory test or specialist treatment). All of the domain experts highlighted this as a special distraction, especially at the beginning of the application usage. According to heuristic evaluation results, application's UI terminology (words, phrases, concepts) is often too computer-oriented, and when this terminology is furthermore used in a wrong way (as the magnifier icon case tackled above), usability can downsize rapidly. Obviously, the guidelines about matching the application presentation with real world concepts were not consistently applied.

The same UI dialogue can be additionally criticized from the standpoint of highlighting a very important information. The red warning icon (placed at the top of the window) indicates that a certain patient can have allergic reaction to some kind of medication substances. Wrong interpretation of this iconic symbol, or missing to perceive it, can have tremendous consequences for the patient. In such a case, the UI design should be oriented to put a stronger emphasis on related crucial information. Just another symbol in the three-icon toolbar is not a satisfactory solution, as there exist better approaches like using modal dialogs (for blocking all other activities until the user confirms a displayed warning message) or changing the palette of the entire window (background color and foreground font color). What is more surprising, the existing icon is not supplemented with any kind of additional relevant information (e.g. tooltip), hence users were forced to learn and recall the associated meaning from scratch.

Finally, results obtained from the heuristic evaluation revealed the need for a much better application help (sub)system. Even experienced users admitted that they sometimes have problems using the application without manual, underlining the rather low support for specific task-oriented questions.

System response time is another issue which is not closely related to UI design, but can also be a significant parameter of overall usability. Domain experts, who use the evaluated application on a regular basis, are very often irritated by the slow and time-consuming process of data synchronization with the central PHCIS server. Data exchange can last for more than half an hour, what results with end user's displeasure ranging from minor annoyance to severe frustration. However, this problem cannot be resolved on the interface design level because it concerns hardware and network issues, as well as the implementation of the central message management system.

Basing on both formal heuristic evaluation and informal discussions with application users, we can conclude that all of the abovementioned usability issues have a deep impact on users' dissatisfaction. The results obtained expose a low usability level of the G2 application, which can be directly related to the lack of user-centered design/implementation principles. Following well known usability guidelines, a number of issues thus discovered could be easily solved, making e-health software support more usable and, at the same time, also making end users more efficient, self-confident and satisfied.

4 Doctor's Home Visit: A Special Mobile Context

Home visits are an important part of general practitioners' (GPs) work as they can get more insight into a patient's general social and economic status, the status of her/his family, and the people that take care of him or her. Knowledge of surroundings and living conditions is an important factor in the general care of a patient. Moreover, home visits can be a part of necessary care for patients with mobility impairments or in situations when home surroundings can have positive effects on patients' health status. However, home visits are a specific part of GPs' work requiring them to use their knowledge and skills without support of instruments and technology possibly at disposal at their institution. In order to analyze this problem we have asked GPs and their supporting nurses and technicians about the general workflow of a home visit. We have also especially investigated the role of the desktop computer stationed at their desks during preparations for home visit and after their return to the office. Before performing a home visit, GPs use the software system to access data about patients: they browse through patients' records and try to get a general picture of their latest status, prescribed treatments and medications. For many of their patients, a short overview of their records is sufficient to recollect important data. (Having, however, more than two thousand patients, GPs admit that as humans they are just not capable of being at any time fully aware of every patient's status [20].) During the home visit, GPs recall data gathered at their desks or use complementary aids in the form of additional printed documentation and their personal notes. Data collected during home visits and further records of prescribed treatments and medicaments is annotated as some kind of paper documentation. These notes are carried back to the desktop computer where everything has to be retyped/stored in the software system. Occasionally, although quite rarely, GPs memorize data produced during home visits, afterward inputting it without written notes, which are then created "post festum".

Considering all data and facts gathered from the interview with GPs we have carefully hinted them the possibility of using some kind of electronic device during the home visit, which will enable the access to (subsets of) data normally available only at the desktop level. At the first mention we have been faced with utter rejection of the notion: it was fully unacceptable to them to have a portable computer such as a laptop by their side during home visits. Laptops were described as heavy, awkward and slow, which GPs commented could just get in the way and slow them down. This latter is certainly true when waiting for the boot and loading processes to successfully conclude, in order to have just a glance at some small portion of data. Other than laptop form factor and the related loss of time, GPs were in general not very fond of the idea of having yet another system they must learn and use. However, they were intrigued by the possibility to have some important subset of patients' data readily available to them without previous preparation whenever they have to visit a patient at home. It was mentioned that a very helpful feature of such a system could be the exemption of having to retype data into stationary computer systems once back in the GP clinic.

Dismissing the idea of laptops as a support device during home visit, we have, yet again, very cautiously noted that there are devices that would much less get in the way but could nevertheless provide the necessary data, naturally hinting at touchscreen devices like mobile (smart)phones and tablets. This suggestion was

partially accepted, in the first place because of the reduced form factor these devices exhibit, but raising anyway a number of questions and starting a vivid debate.

One part of our examinees have been instructed that the software they use at their desk computers is part of a complex system which includes many areas of computing technology; but the question of fitting such an elaborate system into the devices such as mobile phones was promptly answered by the other part of them which are incidentally happy smartphone users. These latter have promptly demonstrated how fast and easy is to use modern smartphones e.g. to find data on the Web, being additionally aware of mobile applications for personal use that enable health record management (e.g. Elevate Mobile's Online Health Portfolio service [21]). The overall conclusion of the group was that although such a solution appears to be technically possible, it needs further thorough investigation. I.e. the idea of having at hand a smartphone and/or tablet application enabling GPs to access patient records during home visit was interesting, however it was very hard for them to make any conclusion without actually using one in a real workset.

5 UI Prototype for GP Mobile Application

In this section we outline a user interface prototype intended to provide GPs with IT support when on a home visit. This prototype naturally follows from the information gathered in the brainstorming session, and is developed using some well-known HCI techniques for software and user interface validation [7, 8, 12, 22]: user interface mock-ups, paper prototyping [23] and storyboard scenario [24]. We reviewed similar cases as reported in the literature [25, 26, 27], concluding that these techniques would produce valuable data in a very resource efficient and time preserving way.

The most probable general scenario of a possible mobile application use during a home visit thus devised consists of the following tasks: (i) finding the patient in the patients list, (ii) opening and reviewing her/his latest medical records, (iii) finding and noting the current diagnosis in the list of World Health Organization International Statistical Classification of Diseases and Related Health Problems (WHO ICD) [28], (v) finding and noting the prescribed medicaments from WHO Anatomical Therapeutic Chemical Classification System (ATC) index [29], and (vi) reviewing the records created. Having defined the general user tasks, we have created six mock-ups, one for each defined task (Fig. 7 – Fig. 9), which we used as faithful representations for possible solutions to the above mentioned problems.

The prototype examinees were members of the group previously involved in the brainstorming session. We asked them, each separately, to set aside about 45 minutes for one final session where they will be presented the idea of a mobile client application supporting home visits.

5.1 Mobile Application UI Storyboard

The story presented to the examinees consists of tasks devised through analysis of data gathered from former evaluation sessions. The first task to be carried out in a real

situation is to find the patient in consideration, which is explained in the first figure in the storyboard (Fig. 7 – left).

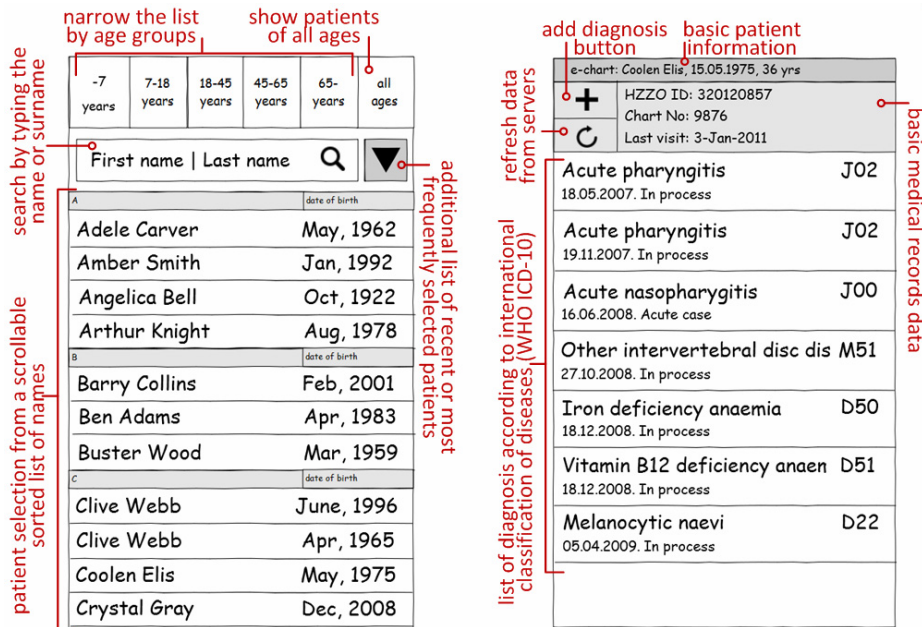


Fig. 7. LEFT: Patient search screen prototype. RIGHT: Screen showing patient's record.

The user interface in this first mock-up (Fig. 7 – left) consists of three vertically placed parts: (i) buttons for selecting the age group, (ii) input boxes for entering the first name/surname, (iii) list of names sorted alphabetically. As previously already noted, GPs in Croatia can have more than two thousand patients, the UI for selecting the right patient has to support the user in narrowing down the list. During our previous interviews it came to our attention that doctors typically use age groups to distinguish between patients groups, and this almost intuitively, leading us to include UI elements to narrow the list of patients according to the age group. After this first step, the user can select a patient either from an alphabetically sorted list or it can further narrow down the list by typing the first letters of a patient's first name or surname. To be able to distinguish between patients with the same name, year and month of birth where included in the patients list. For cases where a doctor has to revisit patient records in the short time after having closed the list, there is a control which will open the list of both the recent and the most frequent patients. Names of selected patients are stored on a stack-like structure, where the latest selected name is put to the front of the list.

Selection of patient name is followed by the screen showing records consisting of patient's diagnosis, date of diagnosis and status of the case (Fig. 7 – right). This screen can be used to swiftly review a patient's status and her/his former diagnosis. The *Add Diagnosis* button is positioned in the upper left corner on the screen of the

application; it is denoted with the plus icon which resembles the Red Cross sign and in the same time symbolizing addition of a new diagnosis.

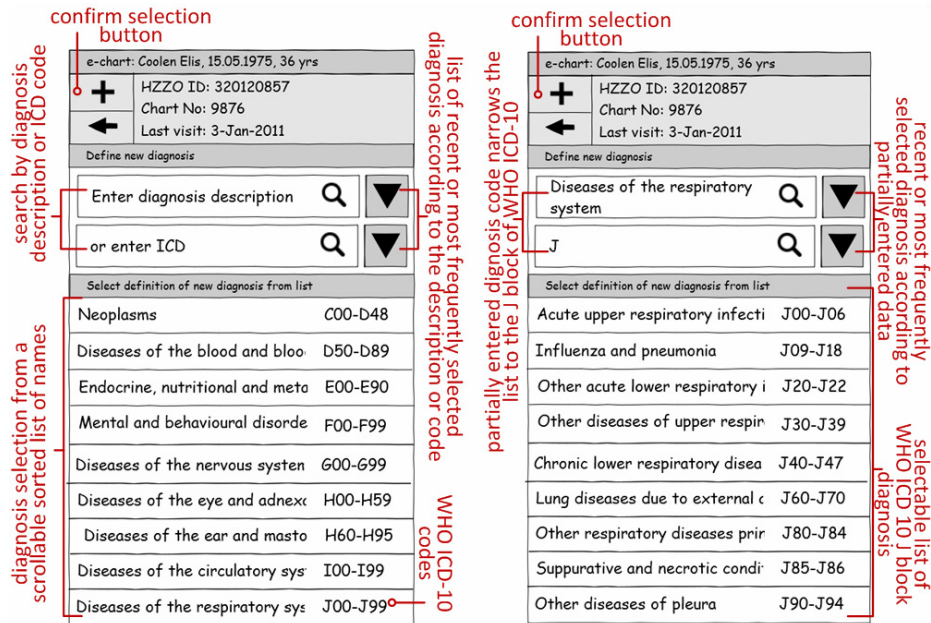


Fig. 8. LEFT: *Diagnosis search screen* showing top level of WHO ICD. RIGHT: *Diagnosis search screen, ICD J level.*

The activation of the *Add Diagnosis* button opens the *Diagnosis search screen* (Fig. 8 – left); here the user (doctor) can select the code of the established diagnosis according to the WHO ICD index. The *Diagnosis search screen* consists of text entry fields enabling the user to enter keywords for finding both the appropriate diagnosis and the filtered list of possible diagnosis, which is displayed below the keyword entry fields. At the beginning, *Diagnosis search screen* shows the top level of the WHO ICD index, with every subsequently performed action leading to diagnosis refinement through a deeper "dive" into the WHO ICD index hierarchy, see Fig. 8 (right). Here the user entered the letter "J" as the diagnosis code, resulting in a narrowed view of the WHO ICD index localized to the J block. Furthermore, the user can select the first entry in the list ("Acute upper respiratory infections J00-J06") from the same screen, and eventually "Acute pharyngitis J02" thus completely defining the diagnosis. If in the process the user makes a mistake, the *Back button* represented by the back ("left") arrow icon can revert this action.

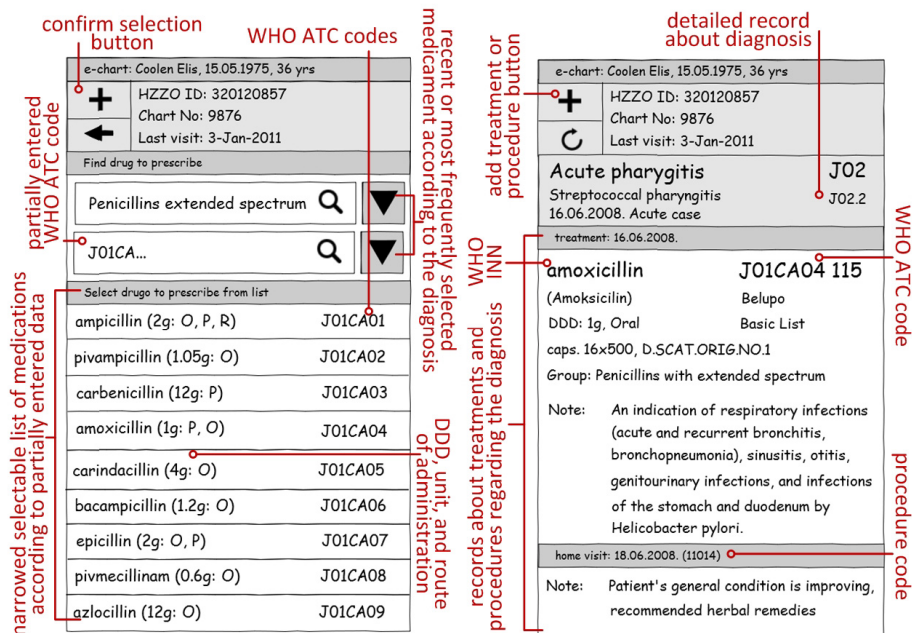


Fig. 9. LEFT: *Medicament search screen* with list of INNs, DDD and administration routes for every medicine. RIGHT: Overview of treatments for specific diagnosis.

The next task in the storyboard is defining and annotating the prescribed medicament. The respective *Medicament search screen* (Fig. 9 – left) is very similar to the *Diagnosis search screen* as both have an identical layout, with UI elements used in the same way, thus following the UI development guideline of providing the user with consistent way to perform analogous actions. Finding the suitable medicament follows a series of actions as previously described in the process of finding the appropriate diagnosis. The difference between these screens consists in the latter displaying a filtered list of medicaments, with each entry comprising the WHO International Nonproprietary Name (INN), the defined daily dose (DDD), routes of administration (O – oral, P – parenteral, R – rectal, N – nasal, ...) and the WHO ATC code.

Reviewing the created records is the final step in the storyboard. To give the user both the sense of control over the process and the chance to ponder on the changes made, the final storyboard screen (Fig. 9 – right) shows both data about the diagnosis defined and the medicaments prescribed.

5.2 Prototype Evaluation

Completing the storyboard, at the end of session with every of our examinees (GPs) we asked them to answer questions (listed in Table 4) about their general satisfaction with the demonstrated prototype. These questions were aiming at evaluating

usefulness and efficiency of the prototype (Q1, Q5), its memorability and learnability (Q3) and examine the willingness to test (Q2) and use the real application (Q4).

Table 4. List of questions for the mobile GP prototype evaluation.

Q1: Grade you perceived overall usefulness of the proposed solution.
Q2: Grade your willingness to test mobile application in real usage scenarios.
Q3: In what extent do you feel confident to repeat the demonstrated scenarios without any help?
Q4: Grade the possibility of mobile application replacing completely the notes written during home visits.
Q5: In what extent do you believe that this prototype implementation could raise your overall efficiency during home visits?

Results thus obtained (see Table 5) show general acceptance of the prototype, and even better, they demonstrate an almost full approval of the notion of mobile application for supporting GPs during home visits.

Table 5. Results obtained from prototype evaluation. Examinees responded to the question list with grades in the range of 1 to 5. Grade 1 denotes poor agreement with suggested statement, while grade 5 denotes full agreement with it.

Examinee	1	2	3	4	5	
Age	45	29	44	35	58	AVG = 42,20
Gender	F	F	F	F	M	
Previous experience with smartphones	Y	Y	Y	Y	Y	
Previous experience with touchscreen smartphones	Y	Y	Y	N	N	
Previous experience with tablet computers	N	N	N	Y	N	
Question	Individual answers					AVG
Q1	4	5	5	4	3	4,20
Q2	4	5	5	4	4	4,40
Q3	5	4	5	3	3	4,00
Q4	4	4	4	5	3	4,00
Q5	4	5	4	5	3	4,20
	AVG =					4,16

Although our examinee group cannot be regarded as a representative sample that would grant conclusive data on the introduction of mobile applications into the PHC software ecosystem, our evaluation shows a clear and positive attitude towards it, along with a willingness to proceed with further investigation of the matter.

It must be noted that thoughtful design of the prototype following the many usability guidelines has brought us positive results. All of the appointed grades in the final prototype evaluation are above 4.0, with the overall grade of 4.16 out of 5, thus backing our claim to consider the prototype a successful one.

6 Conclusion

In the process of introducing the e-health infrastructure together with its related services in the Republic of Croatia, disregard of user interface, interaction design as

well as usability issues in both the official specifications and the G2 client application certification process resulted with implementations which are not based on the user-centered approach. Valuable benefits of the e-health concept are therefore diminished, as primary healthcare end users (especially general practitioners and nurses) must interact with software packages that are not fully tailored to their context and to their needs. Formal evaluation of an existing application for PHC providers, through assessing compliance to Nielsen's heuristics, shows that the related usability level is far from being ideal, hence justifying end users' general dissatisfaction with the provided software support. A number of usability issues (high visual complexity, inefficient selections, poor metaphors, confusing dialogue flow) has been identified as salient application features, forcing users to cope with inappropriate application interface on a daily basis.

Along with the need for much better usability in e-health solutions, PHC providers would benefit from a corresponding set of mobile services. Such an ambition for m-health support especially refers to doctors in the specific context of house visits, where there exists the possibility to employ to a full advantage existing powerful mobile devices such as smartphones and/or tablets. According to domain experts, an appropriate mobile application for managing patients' electronic records "on the move" would be a real efficiency booster.

Our lightweight mobile application UI prototype model is built using well-known usability guidelines, with special care to avoid typical bad design examples found within the desktop solution. Outcomes of the previously performed desktop software heuristic evaluation were very helpful in this process, along with our decision to perform participatory design by including end users in the prototyping process. The final version was considered as very promising, with a high level of simplicity and usability, hence making it a strong candidate to become one of the first initiatives for m-health support for PHC providers in our country.

Acknowledgments. This paper describes the results of research being carried out within the project 036-0361994-1995, as well as within the program 036-1994, both funded by the Ministry of Science, Education and Sports of the Republic of Croatia.

References

1. Ericsson – Nikola Tesla, HR PCIS Functional Specification. Online at: <http://www.cezih.hr/>
2. Ericsson – Nikola Tesla, HR PCIS Data Specification. Online at: <http://www.cezih.hr/>
3. Ericsson – Nikola Tesla, HR PCIS Business Process. Online at: <http://www.cezih.hr/>
4. Health Level Seven International, HL7 Standards. Online at: <http://www.hl7.org/>
5. Ericsson – Nikola Tesla, G2 System Requirements. Online at: <http://www.cezih.hr/>
6. Ericsson – Nikola Tesla, G1 User Certification. Online at: <http://www.cezih.hr/>
7. Nielsen, J. Usability Engineering. Morgan Kaufmann, San Francisco – USA (1994)
8. Holzinger, A.: Usability Engineering for Software Developers. ACM Communications 48, 71--74 (2005)
9. Curtis, B., Nielsen, J.: Applying Discount Usability Engineering. IEEE Software 12, 98--100 (1995)

10. Nielsen, J.: Guerrilla HCI: Using Discount Usability Engineering to Penetrate the Intimidation Barrier. useit.com: Jakob Nielsen's Website (1994). Online at: http://www.useit.com/papers/guerrilla_hci.html
11. Hansen, W.J.: User Engineering Principles for Interactive Systems. In: Proc. Fall Joint Computer Conf. (AFIPS'71), pp. 523--532. ACM Press, NY – USA (1971)
12. Shneiderman, B.: Designing the User Interface: Strategies for Effective Human-Computer Interaction (3rd ed.). Addison-Wesley, Boston – USA (1997)
13. Nielsen, J.: Ten Usability Heuristics. useit.com: Jakob Nielsen's Website. Online at: http://www.useit.com/papers/heuristic/heuristic_list.html
14. Poison, P.G., Lewis, C.H.: Theory-based Design for Easily Learned Interfaces. Human-Computer Interaction 5, 191--220 (1990)
15. Gould, J.: How to Design Usable Systems. In: Helander, M. (ed.), Handbook of Human-Computer Interaction. Elsevier Science, Amsterdam – Holland (1988)
16. Norman, D.A.: The Psychology of Everyday Things. Basic Books, NY – USA (1988)
17. Nielsen, J.: Why You Only Need to Test with 5 Users. Jakob Nielsen's Website (Alertbox). Online at: <http://www.useit.com/alertbox/20000319.html>
18. Hwang, W., Salvendy, G.: Number of People Required for Usability Evaluation; The 10±2 Rule. ACM Communication 53, 130--133 (2010)
19. Glavinic, V., Ljubic, S., Kukec, M.: On Efficiency of Adaptation Algorithms for Mobile Interfaces Navigation. In: HCI'09 (UAHCI). LNCS, vol. 5615, pp. 307--316. Springer, Heidelberg (2009)
20. Miller, G. A.: The Magical Number Seven, Plus or Minus Two: Some Limits on our Capacity for Processing Information. Psychological Review 63 (2), 81--97 (1956)
21. Elevate Mobile Online Health Portfolio Web site. Online at: <http://www.elevatemobile.com/products/products.html>
22. Dumas, J., Redish, J.: A Practical Guide to Usability Testing. Intellect, Bristol – UK (1999)
23. Snyder, C.: Paper Prototyping: The Fast and Easy Way to Design and Refine User Interfaces. Morgan Kaufmann, San Francisco – USA (2003)
24. Quesenbery, W., Brooks, K.: Storytelling for User Experience: Crafting Stories for Better Design. Rosenfeld Media, New York – USA (2010)
25. Holzinger, A., Hoeller, M., Bloice, M., Urlesberger, B.: Typical Problems with Developing Mobile Applications for Health Care: Some Lessons Learned from Developing User-Centered Mobile Applications in a Hospital Environment. In: Filipe, J., Marca, D.A., Shishkov, B., Sinderen, M.v. (eds.), International Conference on E-Business (ICE-B 2008), pp. 235--240. IEEE, Los Alamitos – USA (2008)
26. Holzinger, A., Dorner, S., Fodinger, M., Valdez, A.C., Ziefle, M.: Chances of Increasing Youth Health Awareness through Mobile Wellness Applications. In: Leitner, G., Hitz, M., Holzinger, A. (eds.), 6th Symposium of the Workgroup HCI and Usability Engineering (USAB 2010). LNCS, vol. 6389, pp. 71--81. Springer, Heidelberg (2010)
27. Verhoeven, F., Gemert-Pijnen, J.: Discount User-Centered e-Health Design: A Quick-but-not-Dirty Method. In: Leitner, G., Hitz, M., Holzinger, A. (eds.), 6th Symposium of the Workgroup HCI and Usability Engineering (USAB 2010). LNCS, vol. 6389, pp. 101--123. Springer, Heidelberg (2010)
28. World Health Organization - International Classification of Diseases. Online at: <http://www.who.int/classifications/icd/en/>
29. World Health Organization – Collaborating Centre for Drug Statistics Methodology: ATC/DDD Index. Online at: http://www.whocc.no/atc_ddd_index/