Deriving Usability Goals for Mobile Applications

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ABSTRACT
A starting point in a development of a new application is the identification of an end-user problem that further is translated into usability goals. In this paper, the goals are derived exploring an experience gained from successful mHealth projects. Gartner's report of Hype Cycle for Human Computer Interaction concludes that context-aware applications has already passed the peak of inflated expectations, periods of disillusionment and understanding of the technology's relevance in a domain, and now are entering the plateau of productivity. Although the report explores important for investors indicators of market, investment and adoption activities, the conclusions are relevant for the human computer interaction design, too. One of the sources that generalize understanding of technology relevance is the PricewaterhouseCoopers research that crystallized the principles of successful mHealth projects. As a result, a list of mobile product usability goals is formulated. Literature search allowed compiling a collection of studies that helps defining usability goals for mobile technologies.

Author Keywords
Mobile user needs; context awareness; system acceptability; mHealth applications.

ACM Classification Keywords
H.5.2. [User interfaces]: User-centered design.

INTRODUCTION
Advances in mobile technology allow users to utilize awareness of location, time and surrounding environment while performing tasks. Introduction of a new technology has a potential to be successful when the emerging technical capabilities are combined with a solution that gives a real value for system stakeholders.

In this paper, mobile technology is defined as always available and turned on wireless devices that are intended to be worn, carried, or accessed by the person during normal daily activities. This is in contrast to non-mobile devices that need not to be always turned on. This definition comprises handheld devices such as mobile phones that are working mostly in the background of the main user activities and are used for short specific tasks. The nature of interaction with such devices differs from the work with desktop applications which usually are used for long-lasting tasks and are in the center of user's attention.

Always available and any time accessible mobile applications are pervasive computing software which is part of the ubiquitous computing paradigm. Context-aware computing applications are distinguished from pervasive computing paradigm and enhance mobile applications by taking into account user location, available network resources and device capabilities.

Users expect that new solutions will improve their performance in terms of cost, speed and satisfaction. Exploration of such solutions allows building a common language between technology people and system stakeholders because they tend to think differently. Usability goals build a bridge serving as a communication mean while balancing stakeholders' expectations and technical capabilities [10].

Gartner's report of Hype Cycle for Human Computer Interaction concludes that context-aware applications are entering the plateau of productivity [2]. The innovation trigger for those applications has become an availability of mobile devices to a wider audience. Then, the peak of inflated expectations has resulted in a large amount of various mobile applications. A lot have been only installed, tried to use, and uninstalled. Hype cycle model calls such a phase a trough of disillusionment. The reasons of user disappointment have allowed collecting experience about user needs which were inappropriately supported. Successful developments provided the understanding of the role of a new technology in a domain. They also revealed new opportunities and enabled the slope of enlightenment.

Mobile components became a requirement for nowadays systems. It is worth to analyze experience gained while developing applications. The advantages of sensors and embedded devices should be taken into account. However, just collecting data because the application is able to do so

is not enough. The application should address specific problem.

A large part of mobile applications during the peak was related to the practice of medicine and public health. The integration of mobile telecommunication technologies into the health area is known as mobile health or mHealth [7]. PricewaterhouseCoopers (PwC) report summarizes the analysis of mHealth stakeholders' expectations and aspects of successful technology implementation [14]. It provides stakeholder expectations that are helpful in defining end-user profiles as well as business goals presented in a language of desired technical capabilities. This experience can be transformed to specific questions that help defining usage assumptions of the future mobile application.

The rest of this paper is organized as follows. In the next section, the terms of usability, usability goals and system acceptability for a mobility context are analyzed. from usability goals to acceptability is argued. Then, the expectations of mHealth stakeholders are presented. In the following, the attributes of the mobile system acceptability are formulated in a question form. Finally, conclusions are drawn.

USABILITY GOALS

c The definition provides also three measurable usability attributes: effectiveness, efficiency and satisfaction. Overall, the usability goals refer to [10]:

- end-user profiles,
- tasks that identified end-users are supposed to perform in a given context, and
- business goals that provide measures of successful usage.

Nielsen identifies five attributes of usability [12]: learnability, efficiency, memorability, errors and satisfaction. Comparing these definitions, the metric of effectiveness can be related to learnability, memorability and errors because these attributes affect the task accomplishment. Errors can diminish the efficiency because require more efforts to achieve desired outcomes. Usability attributes are applied to the whole product usage lifecycle from the installation through the first usage, advanced usage and deployment. So, learnability relates mainly to the first usage of product whereas efficiency – to advanced one.

Nielsen usability attributes are derived from desktop applications that are tied to a single location. While using the desktop applications, the user usually performs a single task and concentrates completely on that task. Therefore, the usability attributes for desktop systems concentrate on screen aspects because a screen is usually in the centre of user attention.

The importance of usability attributes differs for desktop and mobile solutions. User goals are different in mobile application and desktop applications. Only mobile applications offer anywhere and anytime access to services [16]. Suppose a user who wants to choose a holiday travel. He can explore various offers on a desktop web site. He is unlikely do this on a small screen. However, mobile components can support time-critical activities like obtaining driving directions during the holiday.

Interaction with mobile applications on the move requires users to divide attention between the screen and physical environment. User may cross the street, interact with nearby people and objects. Therefore, while considering usability of mobile applications, screen aspects express only part of user needs. Therefore, the additional attributes that reflect the context of use should be explored.

One source of metrics that express the context of use is Nielsen's model of system acceptability [12]. Computer system acceptability deals with the question whether the system is good enough to satisfy all the needs and requirements of users and potential stakeholders.

According to Nielsen's model, system acceptability is a combination of its social and practical acceptability. Social acceptability refers to which extent the product impact is approved by different stakeholders. It is important to balance the interests of various stakeholders. Social acceptability of desktop systems can be demonstrated with immersive multiplayer games which are easy to learn and enjoyable to play. However, this can cause addictions and psychological problems in the long perspective.

Practical acceptability comprises cost, support, reliability, compatibility with existing systems and usefulness. The latter indicates whether the desired goal can be achieved using the system. It comprises both utility and usability. Utility refers to sufficient functionality whereas usability refers to how well this functionality is used [4]. Usability is treated here as non-functional system requirement. Its scope is narrower than composition of end-user, task and success measure in the concept of usability goal. The term of acceptability better reflects this scope than strict usability. Therefore, further acceptability goals instead of usability goals will be used

The second source of metrics for mobile applications is PACMAD model (People At the Centre of Mobile Application Development) [5]. PACMAD usability model comprises ISO standard attributes and Nielsen attributes. The cognitive workload attribute is included, taking into account the factor of limited user attention while using mobile application. Overall, the model identifies seven attributes: effectiveness, efficiency, satisfaction, learnability, memorability, errors and cognitive load. Cognitive load refers to the amount of cognitive processing required by the person to use the application. Cognitive load can be measures through the NASA Task Load Index [6] or adopting multifactorial approach [3].

PACMAD model is developed for usability evaluations. It distinguish

EXPECTATIONS OF MHEALTH STAKEHOLDERS

A broad variety of stakeholders take part in mHealth. PwC report contains a comprehensive list of all stakeholders that take part in mHealth [14]. The main groups that express needs for the various suppliers are patients, healthcare professionals and payers (government and private). Technology suppliers have to compromise their interests for a successful adoption. This section presents the findings about expectations of the main stakeholders groups.

Patient Expectations

Patients believe that mHealth offers them easier access to care and more control over their health. Over 40% interviewed patients define their expectations of mobile phones in mHealth [14]:

- learning about or monitoring wellness, e.g., weight, diet, amount of exercise, etc.;
- contact between patient and care provider;
- accessing health call centers, advice lines or emergency services.

Patients would adopt mHealth if it:

- improves access to required information,
- lowers cost, and
- increases control.

For example, patients can enter blood glucose levels into their phones and receive real-time responses from 'virtual patient coach'. mHealth has a potential for chronic disease patients. Always available devices with customized sensors can encourage modifying behavior in an engaging and sustainable way. Diabetes, obesity and hypertension are seen as the three chronic diseases with the highest potential for mobile management through the application [14].

Doctors Expectations

In the interviews doctors expressed the expectations related to mobile health [14]:

- increase efficiency of the contact between patient and healthcare provider;
- monitoring the patient condition or compliance with treatment regimen;
- remote access to electronic patient records;
- communication with colleagues;
- reduction of administrative time and allowing greater time for patients.

Payer Expectations

PwC survey included private and government health insurance entities which pay healthcare services [14]. The top incentives for mHealth adoption are:

- reduction in administrative time for medical personnel allowing greater time for patients (Py1);
- lower overall cost of care for patients by:
  - supporting continuous health monitoring and chronic disease self-management (Py2),
  - encouraging healthy behaviors to prevent or reduce health problems (Py3),
  - reducing the number of healthcare visits (Py4),
  - providing personalized, localized and on-demand interventions (Py5).

There are high expectations that mobile technology will help to increase access to care. This can transform the costly healthcare into less expensive prevention-based patient-focused systems.

Implications For Developers

The stakeholder expectations and successful project experience crystallized the following principles [14]:

- Interoperability with sensors and other devices enables to share data with other applications such as electronic health records and existing healthcare plans.
- Integration into activities and workflows of providers and patients.
- Intelligence in providing real-time, qualitative solutions based on existing data.
- Socialization as information sharing across a broad community to provide support, coaching and other forms of assistance.
- Outcomes in terms of cost, access and quality of care based on healthcare objectives.
- Engagement to involve patients and provide ubiquitous feedback.

In the next section the above-mentioned principles are illustrated with examples of mHealth applications.

EXAMPLES OF MOBILE SOLUTIONS

Developing countries lead in adopting mHealth applications. The paucity of existing healthcare formed a greater demand for change [14]. Mobile technologies are used throughout the healthcare systems [3,9]. Health care workers in the developing world use mobile phones to address critical health needs such as maternal mortality and HIV testing [8].

Embedded sensors enable new methods for collecting biological, behavioral or environmental data improving in the outcomes of medical interventions [9]. A lot of visits to a doctor in traditional healthcare are devoted to measure patient health parameters. Mobile device sensors can monitor those parameters with higher precision, increased frequency, greater convenience, and in some cases, lower cost than traditional measures. A mobile phone attachment CATRA accurately diagnoses and measures cataracts in a fraction of a normal cost [13]. In contrast, proper identification of cataract in developed countries usually requires an expensive equipment and skilled operator.

The fluorescent imaging and sensing platform attached to mobile phone's camera detects dangerous bacteria in water.

This mobile phone attachment helps people to identify when water may need to be purified by boiling [17].

Integrated cameras can be involved in conducting mandate directly observed therapy treating dangerous diseases, such as HIV and tuberculosis. Treatment makes problems to patients such as visiting health clinics daily, waiting in line and taking the pills under the supervision of caregiver. Ongoing VCP-DOT[1] program aims to achieve treatment adherence at least as high as traditional face-to-face therapy at a lower cost and reduced burden to patients and care providers. Patients send videos of taking pills via their cell phones. They are expected to miss fewer doses because of taking them on a schedule that better suits their lifestyle.

Mobile devices incorporating GPS (Global Positioning Satellite) technology provide location-awareness for emergency calls centers by providing the caller location [1].

The CommCare system was introduced to improve efficiency and accuracy for data collection and reporting in resource-constrained settings [11]. Data input through the mobile daily visit forms reduces administrative time of patient data. The time to transfer data from health worker's notes to the medical record database can be reduced from 45 days to 8 hours, in parallel improving data completeness and reducing error rates.

Smart pill box SIMpill[2] assists patients and caregivers in making sure that medication is taken as prescribed. The system registers the events of patients opening a box. In the case patient forgets to take pill on time the system sends him a text message. According to the manufacturer, medication adherence was increased up to 94% [8]. Monitoring happens in real-time.

Sustainable behavior is encouraged through ubiquitous and instant feedback. Medication adherence can be encouraged by simulation games such as PatientPartner.[3] By walking through a virtual role-playing game, patients learn about various clinical outcomes that may result if they fail to adequately manage their health conditions. Monster Manor[4] is a game that engages young children with diabetes to be better at taking their insulin and to have fun.

Mobile devices enable socialization through information sharing across a broad community. It is easier to stay with healthier lifestyle choices while being connected to similarly thinking people. Socializations relates with gamification applications that involve social connectedness, competitions, rankings, status, milestones, immersions reality and personalization by engaging people to take more responsibility on their own health. For example, people, who use Pact mobile application by GymPact,[5] risk loosing money in the case they do not commit to predefined personal goals.

General health information can be provided by mobile information services. Text4baby[6] is the mobile information service designed to promote maternal and child health through text messaging.

ACCEPTABILITY OF MHEALTH APPLICATIONS

The definition of system acceptability goals provides a useful communication means to balance stakeholders' needs and technical capabilities of a prospective mobile application. The user needs can be computerized in various ways. The questions based on acceptability attributes facilitate thinking about context of use from the various perspectives (Table 1). General usability aspects are based on Nielsen's definitions of systems acceptability attributes [12]. Specific mobility aspects are derived from mHealth stakeholder expectations and principles of successful aspects of mHealth applications [14].

Interoperability with various devices and integration into daily activities enables to track user behavior. This property can give users more control over their health, but could also be a matter of concern because people can feel cornered. Social acceptability of such applications has to be considered very carefully.

Practical acceptability comprises cost, reliability, compatibility and usefulness. Patient and payers expect that mobile application allow reducing visits to a doctor. This lowers travel costs. Mobile applications can provide diverse pricing models: limited free version, intermediate versions with moderate fee and fully charged advanced version.

Reliability is a concern of security and privacy. The passive information sharing reduces the administrative workload. However, a privacy protection should be provided.

The compatibility in mobile context involves interoperability with devices which are available in the vicinity. The effectiveness of health care increases when collected data are subject of remote analysis.

[1] Video Cell Phone – Directly Observed Therapy for Tuberculosis, http://gph.ucsd.edu/research/active-projects/Pages/vcp-dot.aspx

[2] http://www.simpill.com/

[3] http://mypatientpartner.com/#theproblem

[4] http://ayogo.com/blog/monster-manor/

[5] http://www.gym-pact.com/

[6] https://www.text4baby.org/

Acceptability attributes		General acceptability aspects	Specific acceptability aspects
Social acceptability		Do product goals correspond to values of various groups of stakeholders?	Is pervasive tracking acceptable for the various groups of stakeholders?
Practical acceptability	Cost	Does price meet performance quality?	Does adoption of the application help to cut costs? Does payment model match user group intentions and financial capabilities?
	Reliability	Is the level of privacy and security appropriate to user needs?	Are the collected data processed ensuring privacy and security?
	Compatibility	Is an application compatible with required hardware and platforms?	Does interoperability with sensors, mobile and non-mobile devices enable passive sharing of data? Is product integrated into existing activities and workflows of users?
	Usefulness	Can system be used achieving desired goal?	Does product offer problem-solving ability to provide real-time, qualitative solutions which are based on available data? Is administrative burden reduced?
	Utility	Does system provide appropriate for desired goals set of features?	Are functions related to specific health problem? Do functions exploit location and time awareness?
	Usability	How easy is to accomplish basic task for the first time? Is an efficient interface alternative provided? Will the user remember how to use system after a long break? How many errors do users make? How severe are they? How easily can users recover from errors? How pleasant is the system to use?	Does the system enable user involvement? Does the system provide ubiquitous and instant feedback to sustain desired behavior? Is communication efficiency increased? Is performance efficiency supported with passive input? Is the connectivity to remote data available? Are specific mobile input and output capabilities utilized in order to reduce a distraction of user attention?

Table 1: System acceptability attributes for mobile applications

Usefulness relates to ability provide adequate information in real time. For example, scheduled recommendation to exercise issued while person driving is rather annoying than helpful. Therefore, the intelligence should be based on time and localization awareness.

Utility attribute refers to appropriate set of functions that enable achieving desired goals. An application has to address a specific health problem. Just collecting data because applications is able to do so can end in failure [15].

Information sharing with peers is important technology adoption incentive. Socialization component is need was expressed by patients as well doctors. Community feedback provides support, coach and recommendations as well as raises motivation.

PwC report suggests including engagement to usability attributes. Engagement is implemented through ubiquitous and instant feedback. The PACMAD model introduces a cognitive load. The latter could be reduced involving the specific input and output features, such as tactile feedback, audio input and output, visual output techniques adapted the small screens, etc. The passive data input is the basic technique reducing manual interaction.

CONCLUSION

The analysis of usability definitions revealed that the term usability and usability goals belong to different level of abstraction. Term usability refers to specific non-functional system aspects whereas usability goals comprise end-users, tasks and measures of usage success. Exploration of system acceptability definition revealed that Nielsen's system acceptability model is more appropriate to analyze the assumptions of the prospective mobile application. This model provides a means to analyze end-user values, tasks and measures of successful usage.

Literature study revealed the value adopting mobile technology in a health care. The stakeholders' expectations help to define the acceptability attributes. The formulation of system acceptability goals is facilitated with provided

questions. The answers support technical people defining assumptions, claims as well as goals.

The study revealed that mobility context does not deny the usability attributes for non-mobile system. They rather complement them with the aspects of context awareness. For example, mobile context augmented compatibility attribute with the interoperability with embedded and environment devices. The collaboration with existing software is as important as in the case of desktop systems.

Traditional usability attributes include engagement and cognitive workload. The ubiquitous and instant feedback can be a powerful motivator for sustainable activities achieving desired goals.

A starting point for design mHealth applications remains social acceptability. Pervasiveness has its positive as well as dark side. It can be really helpful collecting and analyzing data, offering smart alerts adequate to time, location and current activity context. However, it gives huge possibilities to abuse. Therefore, the social impact is the main factor in order to gain the trust.

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