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A Framework Facilitates Development of a Mobile App

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Abstract

Due to the advance of mobile technology, use of mobile devices such as smartphones has been growing rapidly in the U.S. and worldwide. Many health related mobile apps have been developed for care professionals and patients as well. However, studies indicate that there is a gap between science and commercially developed mobile apps. In addition to this, there is no framework to guide devlopment of a mobile app to overcome many challenges and obstacles. Through the development of a pain management mobile app for cancer patients, a framework was developed. A proposed framework was based on the technology acceptance model, ensuring usefulness and ease of use for end users. The first two steps in the framework enforce accurate knowledge translation and communication to build a science based mobile app. Iterative decisions points between steps enhance accomplishment of each step.

Keywords:
Framework, Mobile app, Knowledge translation

Introduction

Due to ubiquitous computing capability, the popularity and access of smartphones has increased in the last few years [1]. In 2017, roughly 77% of Americans own a smartphone [2]. According to Pew Research Center's report, all ages of Americans use smartphones: 92% of age group (18 - 29 yr), 88% of age group (30 - 49 yr), 74% of age group (50 - 64 yr) and 42% of age group (> 65 yr) [3].

The health care domain is not an exception to this trend. Mobile health-based technology has grown exponentially due to ubiquitous computing capability. Patients and care providers are increasingly using health-related applications to educate patients, to prevent and/or treat illness since new mobile technologies are enabling care providers to deliver more effective and convenient care to patients [4]. The same technologies also are encouraging patients to become more physically active, eat healthy foods, and monitor their body and mental status.

Timely information and decision making are essential as an integral part of patients for their own care as well as care providers [5]. In order to facilitate accurate health information and decision-making process of care providers and patients, various mobile health-based apps have been developed [6, 7]. However, studies have found that there is a huge gap between the science of health and commercially developed mobile apps [8, 9]. This is because there are many challenges and no frameworks that guide the developmental process of a mobile app for healthcare purposes [1, 5].

When a mobile app is implemented on a smartphone without considering usability, it decreases end users' productivity, satisfaction and acceptance while increasing end user training time. Therefore, developing a mobile app focused on health care science (e.g. pain, diabetes) and usability is important.

The purpose of this study is to develop a framework that facilitates the design and implementation process of a mobile app through the development of a pain management mobile app (PainSmart) for cancer patients.

Background

Technology Acceptance Model (TAM)

The TAM is an inductive model adapted by Davis from the Theory of Reasoned Action (TRA) model to study the usage of computer software [10]. Generally speaking, the TRA model states that there is a correlation between actual behavior and intention, as a behavior is determined by a person's intention to perform the behavior. In other words, to increase the end users' acceptance, a system should be useful and easy-to-use.

Pain management mobile app (PainSmart)

Accurate and timely pain assessment is critical to high quality pain management for cancer patients [11]. Pain must be tracked over time and frequently reassessed to measure a patient's response to different treatments. Advances in cancer treatments now allow many patients to receive their course of care in an outpatient setting. Evaluating pain that occurs outside of healthcare settings is important for proper and timely pain management and current mobile technology may facilitate accurate and continuous pain assessment [12, 13]. PainSmart mobile app was designed and implemented on Android smartphone to evaluate and recode pain among breast cancer patients at home.

Methods

Unified Modeling Language (UML)

UML is a standard software writing language and was developed based on object-oriented concepts [14]. It gives graphic notations for describing a software system in various views and some preliminary process descriptions for software development. Expressive characteristics of UML facilitates communication between developers and end-users of software. Its ability to specify software components allows UML to build a precise, unambiguous and complete system.

UML: Activity diagram

Activity diagrams in the UML are intended to model the computational and organizational process of a software system. These diagrams are typically used to depict the overall flow of control and the detailed logic in a use case or a scenario. It focuses on the action (task) sequence of execution and the conditions (decisions) that trigger or guard those actions [15].

Step I: Knowledge translation

For algorithms construction for PainSmart, concepts related to pain management tasks and associated elements of each tasks were extracted from the National Cancer Institute recommendations for health professionals (Cancer Pain PDQ®-health professional version). For example, "assess pain level" was identified as a task with associated elements of "intensity", "location", "characteristics" and "duration".

These were converted into activity diagrams (fig. 1) in the Unified Modeling Language, which were representing the logic of the app. An oncology nurse with in-depth patient care experience validated and modified the activity diagrams.

For user interface design, pain assessments and associated sub-assessments were extracted from the National Cancer Institute recommendations for patients (Cancer Pain PDQ®-patient version) and categorized into general pain information, pain level, past and current pain treatments, and patient goals to reduce pain.

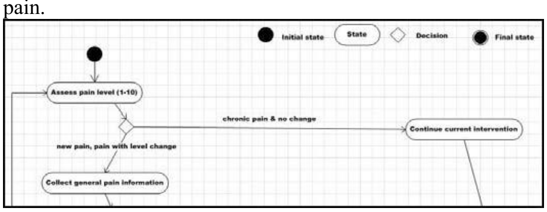

Figure 1– A partial view of activity diagrams depicted

Step II: Knowledge communication

Storyboarding technique

Storyboarding is a popular technique used in filmmaking production [16, 17]. Pictorial representations of story components are prepared and organized sequentially; each picture shows graphic representation as well as explanatory texts.

In order to communicate translated knowledge with a development team, this storyboarding technique was used. During communication, specific user interface layout and components were decided. The development team finalized the storyboard (fig. 2) in a process that required three iterations.

Step III: Prototype implementation

To facilitate effective developments and reduce testing costs, a emulation method was used. PainSmart was emulated in Android Studio© version 2.3.3.

Step IV: Usability testing

Five participants diagnosed with breast cancer were recruited to evaluate the usability of PainSmart. First, each participant was trained to use PainSmart by a research assistant for 20 minutes. Second, a participant used PainSmart alone. Upon completion of PainSmart, each participant completed the System Usability Scale (SUS) with comments.

SUS was used because it allowed quick and easy assessment of a prototype system. SUS has the strong face validity and reliability (α = 0.85) [18].

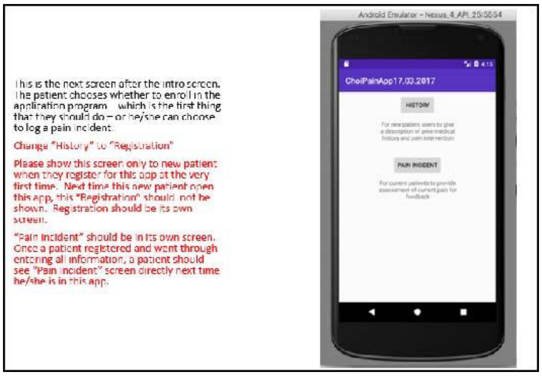

Figure 2– An example of a storyboard

Step V: Final mobile app

Comments from five participants were categorized into either technical issues such as "indicating pain location function is clumsy" or non-technical issues such as "some questions should be written more clerly". Categorized issues were communicated with a development team for the final production.

Results

Step 1: Activity diagrams were depicted with VISIO software (fig 1). Two iterations of validation and modification were needed from an oncology nurse.

Step 2: Seventeen storyboards successfully visualized knowledge translated from pain management guidelines. Each storyboard was a graphical representation of knowledge with explanatory text. Figure 2 shows an example of the storyboards.

Step 3: Figure 3 shows PainSmart emulated by the Android Studio in Windows platform.

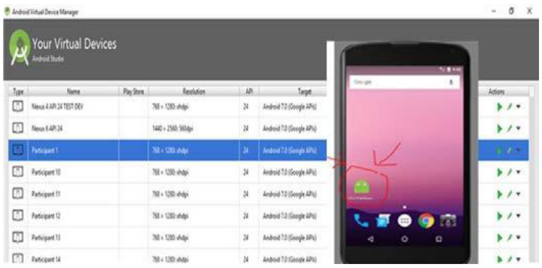

Figure 3– PainSmart in emulation mode in Windows platform

Step 4: The average age of the participants was 59.2 years, ranging from 51 to 65 years and all were white females. Mean SUS was 77.5.

Summarized comments were: 1) Three out of the five participants had concerns with the question revolving the term "recreational drug" 2) Two participants noted the body scale, one said that "it was anatomically correct," while the other stated it was "too big" 3) Two of the five participants had issues with registering and 4) The majority of participants felt the app's questions should be written more clearly and there should be more pain goal options.

Step V: Final mobile app

Final production was not built since it was beyond the scope of this study.

Proposed Framework

A framework representing all of the steps and procedures for developing a mobile app was drawn in a flowchart format (fig. 4).

Step 1: *Knowledge Translation* is defined as identifying actions and decisions from a guideline, that a mobile app should perform. For this initial step, it is important to select an evidence-based guideline recommended by a governmental health organization or national guideline clearinghouse to develop a science based mobile app. A contents expert(s) should validate identified actions and decisions in clinical perspectives and it may take several iterations. Required functions and user interface components should be discussed in this step as well.

Step 2: *Knowledge Communication* is defined as transferring identified logics, required functions, and specific user interfaces of a mobile app to a development team accurately. The storyboarding technique was used specifically in this study due to its expressive nature. However, a project manager, end user representatives, and a software development team can use any tool that is comfortable to them. It is important to use a tool that everyone can understand since logics, required functions, and specific user interfaces of a mobile app should be refined further in this step.

Step 3: *Prototype Implementation* is defined as simulating/emulating a mobile app. Mobile apps are operated in a unique environment, which requires complex and additional testing to ensure the apps' behavior in real world setting functions as intended. Simulation/Emulation testing is highly recommended for an app under development because it facilitates effective developments and reduces testing costs [19]. In this study, Android Studio© was used to emulate PainSmart because it is open source.

Step 4: *Usability Testing* is defined as testing a mobile app by end users in a controlled setting. Usability testing is an important aspect of product development. It requires additional developmental time and costs, however, it is worth conducting because what end-users want and what they perceive are critical for improving the mobile app during developmental stages. An easy-to-use app is desired from end users and key to their acceptance. During this step, easy-to-use features of an app can be obtained for further improvement.

Step 5: *Final Mobile App* is a final step of a mobile app development. Usability testing results are categorized such as technical (e.g. need buttons or menus) and non-technical (e.g. wording of questions on an app should be re-written for clarity) issues and comunicated with a developement team. After improving all issues, a final product of the app is programmed for commecialization.

Discussion

A framework that can facilitate design and implementation process of a mobile app is successfully developed and each steps is explained in details. This framework has several benefits to use. First, it is based on the Technology Acceptance Model (TAM) and integrated TAM's core conepts (useful and easy-to-use) in the framework. If a mobile app development is based on this framework, its useful and easy-to-use features are assured.

Second, the first two steps are specfically for accurate knowledge translation and communication. Iterative validation by content expert(s) in the first step assures knowledge translation from a guideline. Using a tool to communicate knowledge visually in the second step enforces unambiguous knowledge tranfer. These steps ensure that the mobile app will be science based.

Third, since this framework is drawn from the study of developing PainSmart, each step includes detailed and practical tasks. Iterative decisions points are introduced between steps to enhance accomplishement of each step.

Fourth, steps of framework requires involvement of a project manager, software and hardware developers, content experts, end users of a mobile app before it is commercializable. It ensures that the mobile app is sicence based, end-users wanted, and error-free.

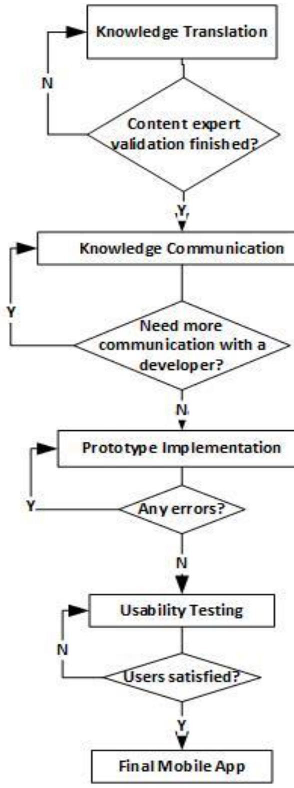

Figure 4– Proposed framework in flowchart form

Limitations

This framework is developed based on one study of developing a mobile app. It should be tested in the development of other mobile apps for further refinement and for generalizability.

Conclusions

Popularity of smartphones among people has increased due to ubiquitous computing capability of mobile technology. In the health care domain, development of mobile apps has grown exponentially to educate patients, provide care and treat diseases. In spite of such demands, there are no frameworks that guide developmental process of a mobile app that is science based, useful and easy-to-use.

Through the development of a pain management mobile app (PainSmart) for cancer patients, a framewrok was successfully developed. A derived framework in flowchart form represents all necessary steps of design and the implementation process of a mobile app sufficiently. Even if it should be evaluated further, this framework shows strong potential to increase efficiency in development of a mobile app.

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