Comparing Literature Claims and User Claims for Mobile User Interface Design

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***Abstract*—The growing number of mobile devices and applications creates huge opportunities for different users and use contexts to employ a range of essential social and economic services. Mobile health (m-health) applications for developing countries seek to improve access to healthcare and health-related information, especially in the rural areas with limited resources. Various healthcare initiatives have been undertaken, both from the governmental and non-governmental organizations, including the Mobile Based Vaccine Stock Monitoring System for rural parts of Ethiopia for timely intervention of out-of-stock and wastage of vaccines. This paper focuses on a pilot program of mobile user interface usability research, seeking to extract claims about mobile interface development and to support and refute claims extracted from literature with the actual user interface design claims examined from the case study. Resulting from this research are different issues and challenges of user interface design, explained both from the designer and user perspective for developing countries.**

***Index Terms*—Mobile User Interface, Claims, m-Health, Low resource setting**

I. Introduction

With the proliferation of mobile phone users in developing countries, there is growing interest both from governmental and non-governmental organizations to make use of the technology to address different social services [1]. The health sector is one of the core application areas for these services. The United Nation (UN) along with governments, civil groups, and other partners are working towards the Millennium Development Goals, with health as a goal of the plan. According to the UN most rural areas of developing countries failed to provide even the most basic health care services [2]. Only a small portion of society in developing countries has access to health care services due to the resource limitation and other factors [3]. As such, a wide range of mobile technology health care applications are being developed and applied in low and middle-income countries [4],[5],[6]. Ethiopia, where this research is conducted, has several m-Health project initiatives from non-governmental organizations and other partners to make health care services better.

In low-resource settings, such as the rural parts of Ethiopia, where both technology and other economic and social resources are limited, it would be sensible to make use of the available infrastructure in an optimal manner. The growing number of mobile phones in developing countries—that have ninety percent penetration in 2014 [7]—comprises one of the potential outstanding resources. Mobile health (m-health) applications that fit this specific situation have also paramount importance. The Mobile Based Vaccine Stock Monitoring System (VSM) application was developed with the intention to maximize use of these resource limitations. This mobile application is expected to improve both the technological and resource limitations by providing a mechanism of management in reducing out-of-stock events and wastage of vaccines.

In making use of the technology, there are various factors that require thorough consideration while implementing in developing regions. These factors include connectivity, low-cost devices, user interfaces, and power [8],[9],[10]. If we focus on appropriateness of user interface, design as a whole has made much progress in the last couple of decades [11],[12] with several research efforts conducted under the umbrella of human-computer interaction. However, the situation of the developing world is only recently a focus area [8],[13]. In line with these, most if not all mobile and mobile applications are designed and tested in the developed world context. Even many mobile devices with low prices intended for developing world are fraudulent copies or imitations, what Wyche calls "dead" phones [14].

In addition, users of mobile in rural areas are often either illiterate or semi-literate. Even making a phone call is not intuitive to illiterate and inexperienced users, and others with reading skills have other factors that hamper easy and comfortable usage. Such factors include a lack of previous computing experience, and language and alphabet barriers (the Ethiopian alphabet (Amharic) is different from English and most handsets do not accommodate it). By considering both technology availability (e.g., device, application, infrastructure) and the context of use/user (e.g., levels of education, previous experience, culture), the mobile user interface design has to be tuned to respond the available situation and requirements of the users itself.

Compartmentalizing the plethora of informal definitions for computer/mobile/computing illiteracy and semi-literacy (but having the definition of computer literacy) for this research, we put forth three types of mobile user.

- *Mobile literate* - able to utilize mobile device and its functionalities and applications efficiently, with a

range of skills from simple cell phone (call and SMS) manipulation to proficient use of other apps and mobile settings, with previous experiences in other computing device (laptops and desktop computers).

- *Mobile semi-literate* - able to make calls but poorly skilled in other functionalities because of a lack of proficiency and previous experiences with mobile and other computing devices.
- *Mobile illiterate* - able to make calls with the help of the others or very poorly skilled to make calls and other mobile functionalities, requiring assistance from others; rarely or never used other computing devices.

In light of these categories, to get the most out of human-mobile interaction (or more specifically mobile user interface design), a designer—and indeed the entire design community—can benefit from appropriate mechanism for capturing the knowledge, dictating and reusing the design, sharing the design with others, and explaining the rationale behind this design. From among the different options of knowledge capturing, sharing and design mechanism, this work focuses on *claims* that capture interface features, upsides, downsides, and rationale [15]. Claims have a history in HCI as a knowledge capture method that can be shared, debated, strengthened, rebutted, connected and reused [15]. Claims are framed as hypotheses that may change based on context, technology, user skills, and other factors relevant to this work. In this research, we identify key claims from the literature and seek to support or refute them based on our mobile application development efforts.

II. RELATED WORK

This research work seeks to explore possible mobile user interface knowledge design, capture, and sharing mechanisms, via claims creation, in developing world situation that can possibly be applied in various m-applications (e.g., m-Health, m-Banking and m-Job search). The particular case study in this paper relates to the m-Health domain, with the consideration of related work is also focused accordingly.

Mobile devices, and more generally ubiquitous devices, can provide information to health care providers at the appropriate time and place [16]. Mobile devices are gaining recognition in the health care industry as a fundamental change agent that can leverage health care services [6]. Mobile technology offers unique potential to address various challenges currently faced by health information systems, allowing for new ways of communication that can provide added value to healthcare delivery [6],[17]. The emerging field of *m-Health* is defined as a "subset of ICT based technology which used mobile device with capability to create, store, retrieve and transmit data in real time between end users for the purpose to deliver health services to patient" [18].

Several m-Health projects are being carried out in low and middle-income countries; such applications include areas like education and awareness, point-of-care support and diagnostics, patient monitoring, disease and epidemic outbreak surveillance, emergency medical response system, health information system, health m-Learning and many more [5]. Most of these m-Health interventions for low and middle-income countries were SMS-based on topics like HIV/AIDS, sexual and reproductive health [19]. There are also various applications developed for low and middle-income countries, such as a mobile application that uses a combination of mobile banking, public information, and free treatment in order to give women access to fistula repair in Kenya [5]; mobile-phone based application to assist community health workers in managing household visits and planning their day, while at the same time collecting and reporting data to monitor and evaluate community health programs in Tanzania [5]; a m-Health platform for researchers, near real-time monitoring capacity of mosquito-borne diseases in Mexico [5]; EpiSurveyor, a free mobile phone- and web-based data collection system used for the collection of information regarding clinic supervision, vaccination coverage, or outbreak response that helps to identify and manage important public health issues including HIV/AIDS, malaria, and measles [5]; and meeting the community health worker needs for maternal health care service delivery using mobile technologies in Ethiopia [20].

m-Health applications, as seen in the previously mentioned literature, generally encounter several challenges in terms of its user interface, which makes the human mobile interaction an important topic of research. Several researchers are working on the usability characteristics of mobile applications, as summarized in [21]. Usability characteristics, like learnability, effectiveness, satisfaction, that are an outcome of interaction of context of use can also be important element of mobile applications [22]. Considering this and other factors, when designing an interface for different user population that have different social, economical and technological backgrounds, appropriate knowledge capturing mechanism to address issues of their own is required [15].

Mobile user interface intended for the developed world may not be best for people in developing countries [14],[27],[28] as characterized by: high percentage of people with low levels of formal education, and with different cultural, economical, and social setting. Wide varieties of issues are involved for this context change and affect the truth [15], such as infrastructure (availability, connection problems, and cost), literacy (most people are illiterate and semi-literate), experience (does not have computing experience) cost (cost of connection, cost of device).

User interface design truths are somehow dependent on the context of use, when the context changes a new design problem may arise. Claims can capture changes in a design truth [15]. The concept of claims was first introduced in the field of HCI in [35]. A claim is a "lightweight knowledge representation" that encapsulates positive and negative tradeoffs of design features [15],[36]. The use of these claims as a knowledge capture and reuse mechanism is also described in different literature [37]. Claims are also hypothetical that can be strengthened, rebutted and debated depending on the change in context. Unlike other knowledge capturing mechanisms such as patterns and cases, claims lack rigor and is good for capturing such requirements [15]. Claims have also shown

promise in encouraging creative design [38],[39]. As such, they serve as the knowledge capture method for this work.

III. APPROACH AND METHODOLOGY

This research involves three distinct but interrelated phases. Each of these phases includes an approach and methodology to analyze the data. Below are the phases of the research, each further described in the subsequent sub-sections:

- Analyzing the literature and creating claims
- Conducting case study
- Comparing the literature with the case study result

Generally, the purpose of applying this approach is to establish and compare a claims set for collaborative health-related mobile applications, resulting in an expanded claims set that provides multiple perspectives on mobile design.

A. Analyzing the Literature and Creating Claims

One approach that we thought helpful and used to create claims from the literature is thematic analysis. We adapt this approach and customize it as shown in the Fig. 1. This approach gives attention on pinpointing, examining, and recording themes within data [23]. Themes can be defined as patterns across data sets that are important to the description of a phenomenon and are associated to a specific research question [24]. Our data sets can be documents and also other data collection instruments (such as academic literature, interviews, questionnaires, requirement analysis documents, etc.). In this particular case, we use different literature (academic papers and books) that was written on mobile interface design and human computer interaction as a data source, seeking a range of different literature to find themes that will result in a list of claims. As one good characteristic of this method important for claim extraction, thematic analysis can facilitate to identify both implicit and explicit ideas within data [24]. We followed an inductive approach since our assumptions are mostly data driven (literature review), not tied to fitting the data into a certain pre-defined framework.

Unlike thematic analysis, extracting claim from the documents and data collection instruments can be done in four phases to create a meaningful theme of claims see Fig. 1. The first two phases, familiarizing with the data and generating initial codes of thematic analysis can be done in one phase for claim extraction - understanding and summarizing the literature. The third phase, searching for themes in thematic analysis is equivalent to identifying list of possible claims concepts. Then, the fourth and fifth phases—reviewing themes, and defining and naming themes—combined together to lead to reviewing and defining claims in claims extraction. And finally, the last phase results in a report that produces a topical claims set.

Phases for Extracting Claims from Literature:

1) Understanding and Summarizing the Literature: This embraces the first and second phase of thematic analysis. It is an initial phase of extracting from mobile interfaces literature to understand and find the required user interface concepts. We extract and summarize key issues related to mobile user interface to identify claims features via an 'issues to be considered repository' (captured in a blog that helps promote both in private and public modes). Explaining and summarizing the literature in a blog can explicitly describe the claims. We also established criteria (a working context), which is commonly called "research questions" in thematic analysis. Our context is defined as mobile interfaces for developing countries.

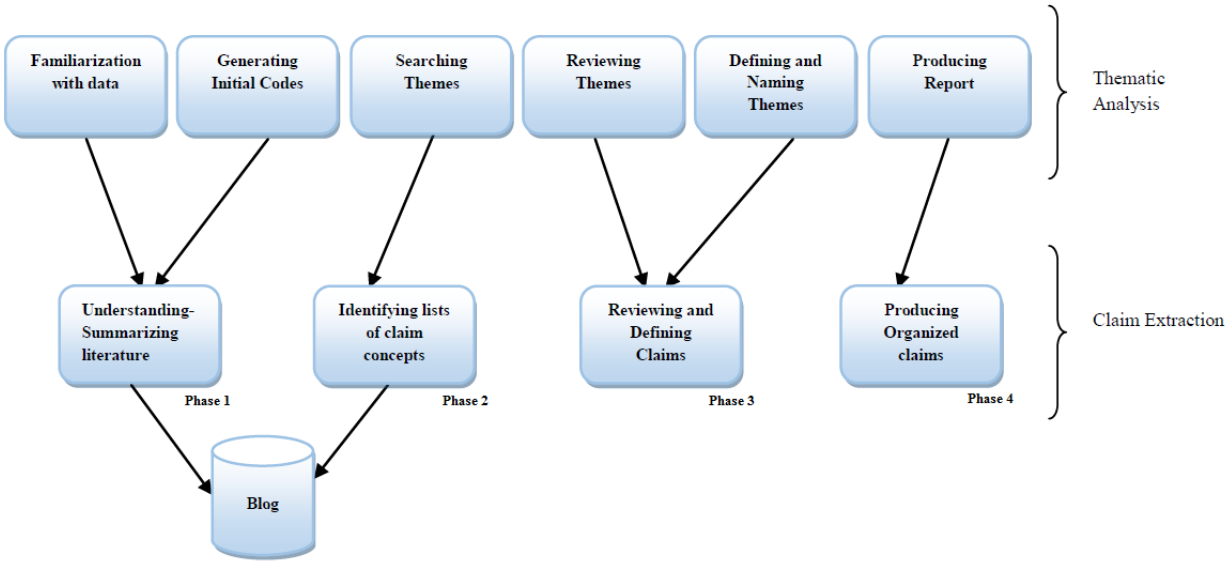

Fig. 1. Thematic Analysis adapted for Claims Extraction

2) *Identifying List of Possible Claim Concepts:* Identifying possible claims, and considering what is important for the context and what is not, enables us to begin the analysis of potential claims in this phase. We manually identify overt and

repeating issues (initial list of claims) in one or more pieces of literature. At this stage, identifying claims requires debate regarding conflicting issues within the literature to identify the reasons regarding the meaning of the identified claims.

3) *Reviewing and Defining Claims:* Claims are hypothetical design concepts with upsides and downsides. Initial claims are very high level and rough, so we tried to refine them by adding, subtracting, combing or splitting candidate claims. It is important to address not only what is present in claims, but also what is missing. Connection and conflict between related claims may serve as important sources of reflection and can inform us to the possibility of new issues for investigation—through further research, design efforts, or experimentation. Defining and refining existing claims that are presented in this phase assists us in analyzing the content within each claims.

4) *Producing Organized Claims:* After reviewing the final claims, we organize and produce a claim that can be referred and used by designers and researchers. It is presented in tabular form having different rows that describe the claims itself.

Claims from Literature

The following are some of the lists of claims extracted from the literature, focusing only on those claims that are relevant to our discussion that can be compared with the case study at hand. Other several important claims are also identified (related to those three types mobile user, such as control menus, handling input (e.g., Text based, Voice based (IVR), graphics), language) and will be presented, matched, tested and converted to design patterns in the subsequent phase our research.

1) *Hierarchical Navigation:* The dictionary definition of 'Navigation' is the process or activity of accurately ascertaining one's position and planning and following a route. Hierarchical Navigation for mobile applications can then be defined as the process or act of going/jumping from one interface to the next possible interface with the intention of accomplishing a task or searching functions (what you are looking for). For an experienced and technology-literate user population, applications with good navigation feel intuitive and are easy to use to accomplish a task [25]. For illiterate and semi-literate user populations, hierarchical menus are difficult to navigate. Particular to these groups, it is difficult to navigate to functions deep in hierarchies as they are less discoverable [26].

TABLE I. MINIMAL HIERARCHICAL NAVIGATION

Claims:	Minimal Hierarchical Navigation
Literature:	Eg. Medhi et al., 2009, Gitau, et al. 2010
Description:	Minimal navigation with two level facilitate function discoverability, minimal completion time and number of clicks.
Upside:	• Easier to find and use the function (function discoverability). • The user would not take long to finish the tasks (minimal completion time). • Getting back to the menu will be one or two click away (minimum number of clicks).
Downside:	• Too much content and/or very limited information to describe what is it (content restriction/ content understanding of user). • Sometime requires scrolling (horizontal and/or vertical scrolling).
Effect:	Result in best mobile experience and promote the use of implemented functionalities.
Consideration:	Two level deep?, Semi-mobile-literate, Applications (such as m-health, m-banking, m-money and so on).

a) Claim 1: Minimal Hierarchical Navigation: Keeping navigation minimal seems to result in a good mobile experience for many user groups [27],[28]. It promotes discoverability of all functions, as these functions are not buried in the hierarchies [26]. If not designed carefully, hierarchical navigation create a long interface chain with users lost, bored, or disillusioned with the interface. It is also important to note that a user might not know how much further to continue looking for a specific function. The tradeoff for reducing the depth of the hierarchy could be either to have more information in a page, requiring scrolling (which has its own downsides) [10].

b) Claim 2: Navigation with Touch Screen: Touch screens operate sensing screen touches and identifying appropriate actions. With the advent of smartphones, touch screens generally replaced other interaction elements (e.g., keyboards, styluses, rollerballs) [29],[30],[31]. As such, designers must identify an appropriate size for text links, icons, buttons, and other interface elements, with each decision supported by design rationale, and designers must decide how much space should be used between different elements. There are various touch screen user interface design issues involved, posing both challenges and opportunities for researchers [30]. In these claims, we condense, aggregate and address the general aspect of the touch screen.

TABLE II. NAVIGATION WITH TOUCH SCREEN

Claims:	Navigation with Touch Screen
Literature:	Eg. Park Y. et al., 2008 , Nicolau, et al., 2012 , Lee et al. 2009
Description:	Interacting with the application physically (with finger).
Upside:	• Directly interacting with the application (pressing convenience). • Does not require to look for keyboard item entry (just clicking rather than pressing keys).
Downside:	• Inexperienced user require plenty of whitespace between tappable elements to avoid accidental clicking (causing incorrect operations). • Links, buttons and other points of interaction need to be bigger and visible for interaction (consistency of clickable elements). • Interacting with a fingers which are bigger than cursor (would be considered in other claims).
Effect:	Navigation with touch screen is easier than keyboards, styluses and rollerballs on mobile devices.
Consideration:	The size of a touch target is a bit larger and visible to recognize, How much big? Semi- mobile-literate, Applications (such as m-health, m-banking, m-money

	and so on).

2) Icons: An *icon* is the small picture on a computing device screen that represents a program or function. Sometimes icon representation differs based on the designer and the cultural settings [33]; as such, cultural awareness is essential in designing icons. Various icons can represent the same referent such that, even for experienced and literate users, some of the icons are confusing; e.g., the globe icon on some phones represents network applications but on others is for the browser [26]. Some icons that are intuitive for many users are difficult to understand for inexperienced users. In addition, the context of the target audience on cultural aspect should also be considered. Consider the next two related claims.

a) Claim - 1 Icon Representation: Icons can visually attract users that might otherwise have a boring experience. Icons that are not meaningful and easy to recognize are very difficult to interpret correctly without training or experience. Icons can save space over textual description, but at the price of recognition (for example, the symbol ⓘ represent information or internet) [26]. For semi-literate users, making things simple is good; however, some textual cue might be required (see the next claim). Even known computing icons might be difficult to understand (e.g., home, save icons).

TABLE III. ICON REPRESENTATION

Claims:	Icon for functions with simple and concise representation
Literature:	Eg. Gitau, et al., 2010, Kim et al., 2005, code4lib, 2009
Description:	Use icons that describe the content/function and provide a preview of the content.
Upside:	• Gives attractive, intuitive and compact representation (Visual plausibility). • Take up less space, does not require long text description (Small space).
Downside:	• Requires previous knowledge of the icon (familiarity).
Effect:	Provide appealing experience in terms of visually and psychologically.
Consideration:	Basic icons, semi-mobile literate, Applications (such as m-health, m-banking, m-money and so on).

b) Claim - 2 Naming Icon: If the icon is intuitive due to its attractiveness, compactness and visual cues nature, then it is generally preferred. However, intuitiveness does not always come naturally (e.g., relying on previous experience of the user). It is assumed that, for a semi-literate user group, naming icons with textual description can make more usable and accessible. However, naming an icon does not require a long textual description, rather a short one or two word cue about the icon (again a challenging thing to find).

TABLE IV. NAMING ICON

Claims:	Naming an Icon
Literature:	Eg. Medhi et al., 2009 , Garofalakis, et al., 2007
Description:	Naming an icon can save time and provide more clear information to the user.
Upside:	• Provide a small textual description to the icon (textual cues). • Labeled icons of application function facilitates good identification (Add identifiability).
Downside:	• Finding an appropriate name with single word that can explain the icon is difficult. • A word or words composed of many characters (long word) adds complexity.
Effect:	Making them easier to recognize and add learnability.
Consideration:	How many characters and how many word (not more than two)? Literacy levels? What applications (such as m-health, m-banking, m-money and so on)?

B. Conducting Case Study

This section presents one m-Health project from the Clinton Foundation Ethiopia for a case study, where the users claims are collected through structured questionnaire, observation, and interviews. This involves both the user and designer of the application.

To set the scene, rural Ethiopia is usually characterized by the following issues:

- Minimal infrastructure, including transportation, electricity, and telecommunication
- Low health care service coverage, including resource limitations (health care professionals, facilities)

Clinton Foundation Ethiopia is a non-governmental organization working on issues related to better health care services for underserved societies of Ethiopia. This branch has developed mobile applications (such as emergency alerts for pregnant mothers, child vaccination tracking) to help the rural or underserved society of Ethiopia. Recently, this organization developed a vaccine monitoring mobile application (the project is at its pilot stage) with the purpose of ensuring availability of vaccines in the stock (i.e., reduce stockout) and providing timely information about the status of each vaccine in terms of usage and expiry date (waste management). This mobile application was installed in the same type of mobile phone (TECNO mobile phone) and given to health extension workers so they can report what is in the stock and what is not.

For the initial stage, fifteen health care facilities were selected in northern Ethiopia. About twenty health care workers (twelve male) participated in two-day training to introduce the system. Fifteen of these trainees have a high school diploma and five have a first degree. Prior to the training session, participants were given a questionnaire consisting of basic demographic questions as well as some mobile use and usability questions. During and after the training we conducted unstructured interviews, observations, and a follow-up questionnaire was administered.

Regarding our definition of semi-literate, all but two of the trainees never experienced other computing device before, beyond use of a mobile for making calls and text messaging. Only two of the participants had used mobile internet. Most of the participants meet our definition of semi-literate mobile users. Before the training, we tried to capture high level claims based on previous mobile user interface experience at granular

level. First, we tried to relate the claims and their previous computing experience. Three common icons (home, save and calendar) were given to the participants. Considering these icons, 17 of the semi-literate users could not identify the icons. The two mobile internet users could identify two of the icons, along with one other user.

Regarding icon preference, almost all the subjects would like to have an icon. Reasons included that it was easier to identify, easier to understand, easier to see everything to identify, easier to communicate, reduces/saves time and cost, quicker, more entertaining, and not boring. Although participants wanted icons, the result showed they did not know common "home" and "save" icons used often in most computing devices. Those who like icons also reflected a desire for text, stating "I can read and understand" such cues. This reflects a preference for both text and icons, also seen in our next phase of research, pattern creation.

Naming functions/contents appropriately is one factor that requires consideration but for which designers and developers often lack coordination. For example in Fig. 2 the icon represented by a view item means “view vaccine”, but during the design stage of the interface the designer thought the interface should include wide varieties of services so he named it “view item”. In the end this product only serves the vaccine stock but the icon remained as-is. During the interview we asked why he left it; he replied that he intended to change it but left it as he thought the effect will be minimal.

As it is important for the user interface to have everything accessible [10], this is difficult for mobile devices with small screens, resulting a long chain of actions to complete a task. Consider one scenario regarding the VSM application, "Issue Vaccine". To issue a vaccine the users have to navigate through all the six interfaces shown in Fig. 2. In the best case scenario, the user has to browse the first four interfaces. This is difficult for them to learn and understand at first, and it is inevitable during the observation that they forget what they are doing during the task.

Another notable finding is that they preferred to navigate using the device back button rather than the application back button placed in the interface.

In touch screen interfaces clickable element should be somehow visible and consistent throughout the interfaces. Otherwise, navigation problems arise. Consider the third interface in Fig. 2, the vaccine detail list form. This form presents each vaccine based on their expiry date priority, with the most forthcoming listed on top. The user has to click the list to proceed, though it is often not intuitive due to lack of experience. Switching from feature phone to smart phone with touch screen seems easy but requires a learning process.

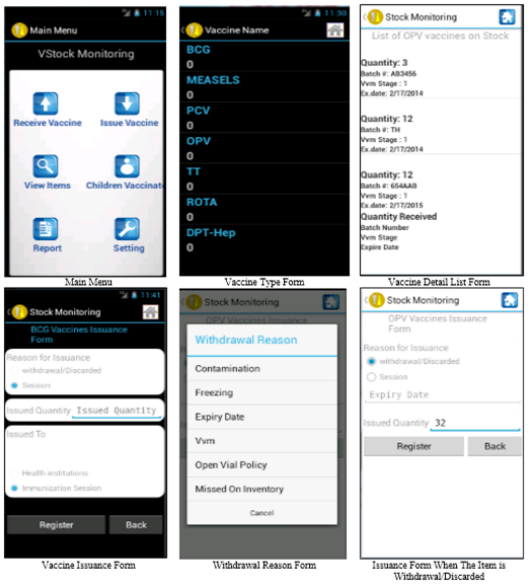

Fig. 2. Issue Vaccine Hierarchical User Interface

C. Comparing Literature with Case Study Results

Following the result of analysis of literature and data collection, the data are analyzed through a pattern matching method (Yin, 2003) to support and refute the propositions presented at the first phase of the research.

Comparing the Claims

The favoring of icons over text in the case study divides the user group into roughly equal numbers; however people who likes the text also wants to have an icon. This somewhat matches our assumption that a combination of both icons and text are important to this user group. Integrating both concisely should increase both understandability and usability. For the case study group, representing functions with icons is highly valued but difficult to understand; this is also supported by our literature claims as one of the downsides of icon representation, unfamiliarity. Naming the icon plays a role in explaining what the icon is, our literature claims proscribes a one or two word function explanation, though that may require many characters (e.g., "children vaccination"). It would be more convenient to have a brief one word to explain the functions. However, finding the right word is difficult!

The minimal hierarchical navigation claims extracted from the literature show that the longer the chain of interfaces, the more difficult to navigate with and lost in somewhere. This is typically noticed in the practical exercises and the observation during our case study training. The VSM applications exceed our literature claims of having at most three levels of navigation. This does somewhat support our literature claim that having a very limited navigational hierarchy is easier to use; however it is not safe to say that three levels of hierarchical navigation is best; more research is needed. In the literature, navigation with touch screens for selecting specific options provided matched our experiences.

Several challenges mentioned by the designer and users can be considered for another user interface claims. A few of the challenges mentioned by the designer include: difficulties in making the navigation hierarchy minimal, tradeoffs of adding functionality and keeping minimal hierarchies, and achieving user interface usability based on user capabilities. The other challenge is in developing applications that fit the many different mobile device platforms.

IV. CONCLUSIONS AND FUTURE WORK

Mobile user interface design focusing on developing countries is an important and timely research topic with many opportunities for advancement. There is promise for advancement and knowledge reuse, particularly if there are appropriate mechanisms for capturing design knowledge, paths for reusing the knowledge, and also avenues for communicating the rationale behind design. Our research explores claims as a candidate for knowledge capture, sharing, and reuse based on their prior use in other domains [15]. This

paper puts forth claims from different sources and considers their applicability to mobile interfaces focusing on an emerging important context, m-health in rural Ethiopia. The results of this research effort shows promise to advance claims extraction from the literature balanced with actual users claims. In many cases there is a close match, but most importantly it provided the opportunity to further extend the claims set. It was also important to test and see results for claims regarding populations lacking in mobile literacy.

Future research will further seek other possible ways to extract claims from interviews, questionnaires, and other resources. The research will also continue to identify claims from documents, along with extensive actual case scenarios focusing on m-health and m-banking. Other claims extracted from literature (such as menu controls, scrolling, contents, languages and more) will be addressed through other similar scenarios. In the end, we anticipate generating a claims set important for m-health in developing areas that is rich with design rationale and decision making mechanisms in support of human-computer interaction and user interface patterns.

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