Categorizing Mobile Health Project Evaluation Techniques

Full Paper

Alan Yang
Georgia State University
ayang5@gsu.edu

Upkar Varshney
Georgia State University
uvarshney@gsu.edu

Abstract

Mobile health has received some serious attention in research and development community. Although very promising, the evaluation of mobile health is one major challenge without much guidance on what evaluation techniques are appropriate for given scenarios. To address this challenge, we create a taxonomy of evaluation techniques from a sample of 64 mobile health (mHealth) projects. The research problem and scope is first defined through a literature review on the fields of mobile health and project evaluation. This is followed by a description of the methodology of taxonomy development and a description of the categorization process of the observed evaluation techniques from the sample. Following creation of an initial taxonomy, we present the findings from the categorization process and discuss their implications on both the mHealth and project evaluation fields.

Keywords

Mobile health, taxonomy, health information technology, project management, project evaluation

Introduction

The mHealth Economics 2016 report predicts that the mHealth application market alone will grow by 15% to reach $31 billion by the year 2020, with the entire mHealth market projected to be worth $59.15 billion (Jahns et al. 2016). Despite the growth of industry, effective evaluation of mHealth projects has remained an area of limited focus in the field. This research project seeks to create a meaningful classification of existing mobile health literature and to provide useful tools in the form of design science artifacts for researchers and practitioners in the mHealth field to utilize.

Research has shown that lack of effective project management techniques leads to a higher rate of project failure. An oft-underdeveloped part of projects is in the evaluation of goals and objectives throughout a project's lifecycle. Existing studies focusing on the topic of evaluation in mHealth either cover the topic on a case-specific basis or address the issue within a very specific medical context (Whittaker 2012). Evaluation as a concept is not foreign in the HIT fields, but there are no studies which include both empirical findings from literature and incorporate theoretical frameworks to create guidelines for effective mHealth project evaluation (Brown et al. 2013; Ybarra et al. 2014).

By creating this classification system for mHealth project evaluation techniques, we hope to provide a guiding point for both practitioners and researchers involved with mHealth projects. Effective project evaluation will lead to more knowledge being disseminated throughout all stages of the project. Increased knowledge amongst managers and researchers will then lead to better utilization of resources for future mHealth projects and maximize the value to be gained from the rapidly growing mHealth industry.

The primary research question is as follows: "What are the most widely used techniques for evaluation of mHealth projects?" The main research contributions of this study are the organization of mHealth project evaluation techniques into a taxonomy and the subsequent analyses of the resultant dimensions and characteristics. A method for guiding mHealth project development and research will then emerge following the creation of this classification system. The data informing the method will be derived from the entities within the taxonomy.

The overarching goals of this research project are to apply a process for categorizing information in the mHealth project management literature and to create actionable suggestions for individuals working in

the field. The research will be based on established guidelines of taxonomy development and the contributions will be presented as design science artifacts.

Literature Review

Most work that has been done in classification of mHealth project characteristics has been in the form of literature reviews summarizing the state of the field (Aranda-Jan et al. 2014; Dwivedi et al. 2016; Hickson et al. 2015). These summations of existing work in the field of mHealth are helpful and provide insights, but are not driven by a specific guiding principle or offer a benefit beyond a picture of what has been accomplished so far in the discipline. The mHealth taxonomy we offer is meant to address the gap in research for a targeted, systematic classification system of project evaluation techniques. This section offers definitions of terms in the fields of mHealth and project management to ground our work within the current research dialogue. Furthermore, by clarifying definitions, the scope of our contribution is made clear.

Mobile Health (mHealth)

We define mHealth as any system that is enabled through an established wireless infrastructure which provides healthcare to individuals in a manner that lessens the impact of both spatial and temporal constraints (Varshney 2014; Varshney 2007). This does not imply that every individual member of a system needs to possess continuous connectivity for that system to be considered as an instance of mHealth implementation.

What constitutes an ideal mHealth environment is a subject of debate. Discussions on the subject revolve around two characteristics of mHealth systems: the network and infrastructure the mHealth implementation is being deployed on and the well-being of the users that are within the system. Both characteristics then branch off into multiple facets, with subjects such as security, reliability, and functionality identified as important qualities to maintain for an infrastructure (Kotz et al. 2009; Doukas et al. 2010; Varshney 2014). On the user side, both patients and providers are collectively considered users of the system. Measures of quality discuss how effectively individuals utilize the mHealth system, gain information from it, and use that information to improve their own lives or the lives of others (Asangansi et al. 2010; Barton et al. 2012; Demiris et al. 2008).

However, within the current field of research there is a lack of evidence proving the actual utility resulting from individual projects, particularly in low-income countries (Bastawrous and Armstrong 2013). This lack of evidence-based research creates both an opportunity along with a sense of urgency for researchers in the field. As mobile technologies become more widely adopted worldwide, individuals and organizations may attempt to implement mobile health-related projects utilizing technology without a set of guidelines and standards that were created from objective analysis of existing mHealth implementations.

Preliminary attempts have been made at creating a taxonomy for making sense of the rapidly changing m-health environments, but the studies do not incorporate a theoretical component or go beyond the planning phase to the implementation and evaluation phases of mHealth project management (Olla et al. 2015, Plachkinova et al. 2015). An opportunity exists within the mHealth field for the creation of a classification system that can both relate to theory and test existing projects. Creation of such a taxonomy can lead to practical contributions in the development of new mHealth project management techniques and can contribute to the IS literature by clarifying the information that currently exists.

Project Management

The project management discipline seeks to achieve an optimum balance between the competing constraints of funding, time, and scope. The project management body of knowledge, or PMBOK guide, divides the sections of a project into 47 separate processes grouped into five process groups: initiating, planning, executing, monitoring and controlling, and closing. The field of evaluation is linked closely to that of monitoring and control and seeks to determine whether a project is meeting its stated goals.

Within the IT discipline, factors such as product quality and project risk are considered as important to achieving project success as maintaining the ideal balance of resources (Schwalbe 2015). Effective project

management has been observed to confer a series of benefits to multiple project stakeholders, including the following:

- Better control of financial, physical, and human resources
- Improved customer relations
- Shorter development times
- Lower costs
- Higher quality and increased reliability
- Higher profit margins
- Improved productivity
- Better internal coordination
- Higher worker morale

Individual projects can be divided into multiple stages to better conceptualize the timeline of an activity. A commonly used framework within project management divides the stages into three parts: the planning stage, the implementation stage, and the evaluation stage. Within the planning stage, the objectives and constraints are presented and analyzed, typically by a team planning the project such as a steering committee. The actualization of the planning takes place in the implementation phase with evaluation usually occurring after implementation to measure the effects of the project and determine whether the stated goals were achieved (Schwalbe 2015).

Further research on the field of evaluation has determined that the two main reasons for evaluation in projects are to provide information on whether established goals are being met and to generate new insights from project outputs (Frechtling 2002). Writings on evaluation during the last 20 years have focused on the connection between the evaluation and implementation processes. New evaluative techniques promote more evaluation taking place throughout the implementation phase of a project. This is contrary to the more traditional role of evaluation taking place after planning and implementation. New techniques such as developmental evaluation have emerged from the idea that the three cycles of implementation, planning, and evaluation are inherently linked.

Health information technology presents a unique setting for applying the techniques of project evaluation. Some of the major obstacles associated with the field are the numerous problems that arise throughout the course of a project and the nuances in choosing the correct item to evaluate. Related to these problems are metrics of success and failure, which can vary widely from project to project. For instance, two developers for a medical app may have different definitions of project success. One developer may view getting an app onto the market as a success, while the other has a goal of 1,000 concurrent users, with anything less being a waste of resources. While extreme, this illustration demonstrates that evaluation metrics of success and failure can be heavily dependent upon the context in which they are being applied. Many of these problems have been traced to sociological, cultural, and financial challenges unique to individual projects but consistent to similar problems other projects face (Kaplan et al. 2009). Collaboration between specialties, stakeholders, implementers, and clinicians creates unique difficulties and can result in "culture clash" when previously understood standards and practices within a group are not interpreted or adopted by another. Recent studies on project management techniques argue that a soft paradigm and hard paradigm exist for analyzing different problems. Hard paradigms tend towards treating problems as obstacles to be solved, whereas soft paradigms perceive problems as pieces of a puzzle to be structured and overcome in an optimal fashion (Pollack et al. 2007). IS project managers have become more accepting of the soft paradigm in recent years due to the shifting nature of project goals and additional difficulty in creating stable metrics.

Finally, meta-analysis research in health information systems posits that many factors are making traditional project management techniques less effective and exacerbate problems that occur (Haux et al. 2006). A short list of the shifting field of HIT is as follows:

- A gradual shift from paper-based to computer-based storage and processing of information
- Immense data increases and a larger demand for effective analytical techniques
- Expanding scope of projects, beyond hospital-level towards country- and global-level of health information systems (HIS) development
- Expanding scope of evaluation metrics and an increased focus on patient-centric metrics beyond provider-centric metrics
- The growth of public health as a discipline and emphasis on clinical and epidemiological research

- Change management and strategic information management as important components of projects beyond technical aspects
- New technologies such as ubiquitous computing and sensor based technology being incorporated into patient care techniques

The solutions to address these rising issues revolve around the development of methods for strategic information systems (IS) management. Education of project stakeholders through modeling and evaluation techniques can ease the transition towards new technologies and allow for minimal disruption to teams adapting to the new challenges in the field of HIT.

Methodology

This research is positioned as design science research with the primary output the creation and evaluation of a taxonomy artifact of mHealth projects. Design science artifacts have been described as either a construct, model, method, or instantiation. The construction of the taxonomy is presented as the formation of a model. The reasoning for following design science is that the methodology is meant to solve the phenomenon of "wicked problems". mHealth projects fall underneath this description of wicked problems by being positioned within a complex socio-technical environment with no one-size fits-all solution.

Justification as Design Science

Alan Hevner proposed in a 2004 paper seven guidelines for design science research. Mapping each guideline to a related task defines the methodology and clarifies the way in which the research is adherent to design science principles. The exercise of connecting parts of the research to the guidelines also has an added benefit of creating a high-level overview of each major milestone in the project.

Guideline 1: Design as an Artifact

The goal of this research proposal is to create an artifact as defined by March and Smith 1995: A taxonomy for mHealth project evaluation techniques.

Guideline 2: Problem Relevance

Through the literature review of the proposal, mHealth is demonstrated to be a timely problem with complex characteristics that make effective evaluation difficult (Ammenwerth et al. 2003). More broadly, the field of HIT has grown tremendously in the past twenty years and effective evaluation techniques and standards have been identified as key areas that need to be addressed if the discipline is to expand. Current research shows that the field of mHealth will not diminish soon, meaning that existing problems will at worst persist, but will more likely grow in the coming years.

Guideline 3: Design Evaluation

Evaluation of the taxonomy will follow the guidelines suggested in Nickerson et al. 2013. Evaluation of the methods will be through comparisons to extant theory and frameworks in the field of project evaluation and examination by a panel of experts. The research cycle of the project follows the iterative design-evaluate cycle proposed by Hevner 2007 as well as the ex-post and ex-ante classifications defined by Pries-Heje et al. 2008. A series of weighting systems will be utilized to determine the impact of various attributes within a taxonomy. Expert analysis of both the taxonomy and method will serve as another form of evaluation and help to generate new insights throughout the iterative design cycles of the research endeavor.

Guideline 4: Research Contributions

Theoretical contributions of this research are the modification of theories, frameworks, and models in the healthcare, project management, HIT, and public health disciplines. The inherently inter-disciplinary nature of the work will help to create new solutions to complex problems in the information systems field. Practical contributions of this research are a better understanding of the role of evaluation in the information systems field and the possible development of new assessment practices and principles.

Researchers can also benefit from the taxonomy by observing the common characteristics among current mHealth projects and identifying opportunities for future research. Theoretical applications can uncover new characteristics on both the individual and project-level that can explain the aptness of different assessment measures and procedures.

Guideline 5: Research Rigor

The primary motivation for the research is a lack of taxonomy development in the field of mHealth and HIT grounded in empirical data derived from analysis of mHealth project management literature. Rigor is demonstrated through adherence to procedures of taxonomy development and inclusion of frameworks, models, and theories from the fields of project management, HIT, and mHealth to the design and evaluation of the taxonomy.

Guideline 6: Design as a Search Process

The three-step process of taxonomy development and the proposed research process are consistent with the definition of iterative design and evaluation. Development of the artifact will lead to evaluation which then feeds back into further development as revisions are made. New information gathered throughout the cycles is included to generate more comprehensive and effective artifacts.

Guideline 7: Communication of Research

Communication of the research is the dissemination of the taxonomy to researchers and practitioners.

Taxonomy Development

The creation of the taxonomy follows the guidelines described and implemented in Nickerson et al. 2013 (Figure 1). This model was chosen because it adheres to the taxonomy development literature and is a useful way to categorize information.

The meta-characteristic for this taxonomy was determined to be as follows: project evaluation techniques within the field of mobile health. By determining the meta-characteristic at the first stage of taxonomy creation, we prevent several issues from arising later. First, the meta-characteristic focuses the search during the approach stage and prevents a random filtering of the literature. The meta-characteristic also guides the creation of the taxonomy throughout the entire process.

For step 2, ending conditions for the taxonomy were established before the papers from the sample were analyzed. The criteria for ending conditions were evaluated based on the guidelines proposed in Nickerson 2013 of both subjective and objective ending conditions. The objective conditions are as follows: 1) All objects of a representative sample of objects have been examined, 2) No object was merged or split in the last iteration, 3) At least one object is classified under every characteristic of every dimension, 4) No new dimensions or characteristics were added in the last iteration, 5) No dimensions or characteristics were merged or split in the last iteration, 6) Every dimension is unique, and 7) Each cell is unique.

Nickerson 2013 also proposes a series of subjective ending conditions to measure the merit of the finalized taxonomy. The subjective conditions are as follows: 1) Taxonomy is concise, 2) Taxonomy is robust, 3) Taxonomy is comprehensive, 4) Taxonomy is extendible, and 5) Taxonomy is explanatory. Step three involves a decision point indicating what type of approach is to be taken in creating new dimensions and characteristics for the taxonomy. We chose to follow the empirical-to-conceptual track to obtain a representative sample. This task is followed by the formulation of initial dimensions and attributes.

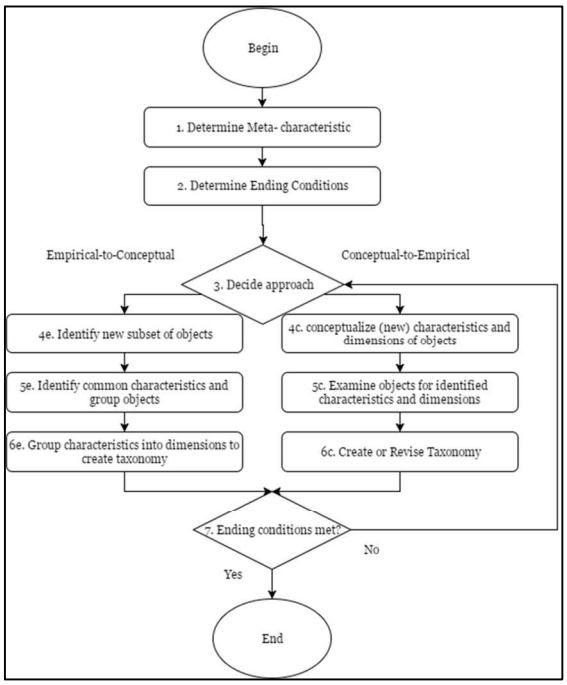

Figure 1. Taxonomy development method (Adapted from Nickerson et al. 2013)

At stage 4e, empirical data was obtained through a review of the literature. We conducted a search for the terms "Mobile health", "mHealth", and "m-Health" in conjunction with the terms "project evaluation", and "Evaluation" on the academic databases Web of Science and IEEE explore from January 1 2000 to May 2016. The search terms were decided based on the meta-characteristic determined in step 1. Combined, various permutations of the search terms yielded over one-thousand results. Papers were then further narrowed through identification of shared characteristics. Papers that did not specifically deal with a form of mobile health implementation in a project setting were not considered for the taxonomy. Filtering at this level resulted in 64 papers identified as relevant and formed. These papers were then used as our sample from which we created the dimensions and attributes of the taxonomy.

The papers were analyzed which then led to the emergence of shared themes and patterns. This lead to stage 6e, where the dimensions and characteristics of the initial taxonomy were formed. The dimensions and characteristics, along with the number of unique occurrences for each attribute, is presented in Table 1**.** Seven dimensions were identified, each with two attributes. The first three dimensions each map to a different concept of project evaluation: stakeholder management, cost management, or quality management. These dimensions grouped projects based on whether they had some form of evaluation focused on that element of the project during either the implementation phase or the summation phase. Application development indicated whether a mobile application was used. The study duration determined the length of the projects, either up to six months or exceeding six months. This was used as a baseline since the range of the projects typically were half a year to a full year. Few projects exceeded one year in length. The determinant of success is linked to whether a provider-centric or patient-centric metric was used as the primary means of evaluation for the project. Finally, the project setting was determined by the country the study was conducted in.

The ending conditions were checked and met after this final stage, leading to a taxonomy of evaluation techniques with 7 dimensions and 14 attributes total, populated by 64 entities of documented mHealth projects. General observations of the taxonomic groupings show that most projects within the sample have some type of stakeholder management, are unlikely to have a form of cost management, and vary on the remaining dimensions. There is a propensity to have a type of quality management and most studies are shorter term (up to 6 months maximum) and take place in a developed country. Both the existence of

application development and chief determinant of success dimensions had an even split of entities populating the two attributes. This reveals that within the healthcare setting, mHealth projects do not always have to have an application associated with them. Likewise, there are as many projects focused on patient well-being as there are projects meant to imp rove the effectiveness of healthcare providers.

Stakeholder Management	Yes	55
	No	9
Project Cost Management	Yes	17
	No	47
Project Quality Management	Yes	44
	No	20
Application Development	Yes	30
	No	34
Study Duration	0-6 Months	38
	6+ Months	26
Determinant of Success	Provider	32
	Patient	32
Project Setting	Developed Country	41
	Developing Country	23

Table 1. Unique occurrences within Dimensions

	Developed	Developing
Stakeholder (Yes)	35	23
Stakeholder (No)	9	0
	Developed	Developing
Cost (Yes)	10	6
Cost (No)	31	17
	Developed	Developing
Quality (Yes)	28	7
Quality (No)	13	16

Table 2. Observations between setting and evaluations

Table 2 shows the connection between project setting and the existence of a form of evaluation targeting one of the three dimensions in the taxonomy. Of note is that in all cases where studies took place in a developing country, there was some form of stakeholder evaluation during the project. Evaluation of quality was also much more common in developed countries.

Discussion

The creation and analysis of the taxonomy revealed many findings about the mHealth field in general. First, that while project management techniques are being applied to many projects, the focus tends to be uniquely on either stakeholders or quality. Cost-based metrics are rarely used and few studies divulge the financial data associated with their projects. Second, the term stakeholders is broad and varies widely between projects. Some projects considered the end-users of the technology as the primary stakeholders for analysis, while others incorporated management teams and government organizations as additional groups of interest. All studies which took place in developing countries within the sample had some component of stakeholder analysis. This typically focused on the end users, but another common theme was a discussion of the major governmental organizations that either funded or oversaw the implementation of a project. The few projects that did address this area focused more on the technical non-human aspects of the project. For instance, two out of the nine projects that did not incorporate stakeholder analysis instead focused primarily on the reliability rates of the mobile network the technology being implemented was based on.

Cost analysis is less common among projects. A common theme that is echoed throughout multiple projects is that mobile technology has the potential for cost savings in comparison to extant forms of healthcare. However, only a few papers go into detail and compare the relative cost of healthcare both with and without a mobile health component. Finally, the term of quality also took on a number of meanings between different projects. This phenomenon is consistent with the observations made during the literature review, that the nature of the ideal mHealth environment is not something that is unanimously agreed upon. Multiple projects used characteristics related to data as the primary metric, such as data security, reliability, or usefulness of the data. Multiple studies discussed the importance of data interpretation, particularly if the end-users were not familiar with mobile technologies.

Potential Theoretical links

These findings have potential theoretical application. Both contingency theory as well as concepts within the field of information security can play a role in interpreting the relationship of mHealth and project management principles. Contingency theory states that there is no one optimal solution for any given organizational problem (Hofer 1975). The theory espouses the importance of examining the different factors affecting an organization to determine the most ideal form of organization at that moment. Similarly, there is no single best way to perform evaluation for all mHealth projects. For instance, the prevalence of stakeholder evaluation taking place in mHealth projects in developing countries could be an indication that developing countries create an environment or situation that leads project managers to focus more on ensuring stakeholder support.

Multiple studies mentioned information security and the safeguarding of information as a key priority in assessing whether a mHealth project was successful. The confidentiality, integrity, and accessibility triangle framework from the data security literature could lend some standardization to these discussions. The three aspects each describe an aspect of transferred data to be accounted for (Von Solms et al. 2013). Confidentiality means that only those meant to see the data see it. Integrity ensures that the data has not been compromised or altered when it arrives to its intended destination. Accessibility states that the data is available and able to be accessed by authorized individuals whenever it is needed. mHealth data lends itself to this framework, reliability and network stability are already considered measures of a mHealth system's effectiveness, each can be mapped to the construct of accessibility. Descriptions of the security of mobile data throughout the projects within the sample can all similarly be mapped to the concepts of confidentiality and integrity.

Practical Contribution

In addition to the theoretical connection, this taxonomy can be observed and expanded upon both by project managers and researchers working in the field of mHealth to better improve the efficacy of evaluating projects. For instance, the prevalence of stakeholder evaluation occurring in developing countries may indicate to a manager of an mHealth project within a developing country to include some form of user testing within their project. On the other hand, the lack of cost-analysis within all mHealth projects could indicate an opportunity. An mHealth project manager seeing this trend may then seek to incorporate some form of cost-benefit evaluation within their own undertaking to differentiate themselves from other projects and better document the effectiveness of their own mHealth intervention.

Conclusion

From our research, we have observed how project management techniques are being applied in the mHealth setting. To accomplish this task, we have created a taxonomy of evaluation techniques used in recent mHealth projects. The taxonomy reveals that there is still no clear definition of what constitutes quality and that few projects track the financial impact of mHealth implementation. Moving forward, mHealth researchers and project managers can use this information to better inform their decisions when determining how to evaluate their research and projects. Future applications of this work can lend to better standardization of evaluation methods, more consensus as to what constitutes quality in mHealth settings, and ultimately shape better, more effective solutions to unsolved healthcare problems.

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