# Improving Consumer Health IT Application Development: Lessons From Other Industries

# Background Report

**Prepared for:**
Agency for Healthcare Research and Quality
U.S. Department of Health and Human Services
540 Gaither Road
Rockville, MD 20850
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HEALTH IT

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# Executive Summary

## Background

In *Crossing the Quality Chasm*, the Institute of Medicine outlines six aims critical to transforming health care delivery. One of those aims is the delivery of patient-centered care, "care that is respectful of and responsive to individual patient preferences, needs, and values and ensuring that patient values guide all clinical decisions" (Institute of Medicine 2001, p. 40). Central to the vision of a patient-centered health care system are information technologies and tools in the form of consumer health information technology (IT) applications that support a range of health management activities such as storing and retrieving health information, sharing health information with health care providers, and tracking health-related behaviors and actions. However, despite the acknowledged value potential of consumer health IT applications in regard to improving health management, growing market offerings of consumer health IT applications, and vocal advocates of the technology, at the present time there is insufficient adoption and diffusion among consumers.

To address the need for accelerating the development and diffusion of consumer health IT applications, The Agency for Healthcare Research and Quality (AHRQ) commissioned this report as a key deliverable for the task order entitled "Understanding Development Methods from Other Industries to Improve the Design of Consumer Health IT." The task order's findings will constitute a foundation of recommendations intended to guide the development of consumer health IT applications. This report summarizes and synthesizes findings related to design methods used for the development of successful consumer products in industries other than health care. It offers recommendations for developers of consumer health IT applications and provides directions for future research.

We used multiple sources of data for developing this report and recommendations. One source of data was an extensive environmental scan of the peer-reviewed and grey literatures for (a) prior work related to core concepts in product design such as design philosophies and design methods, and the stages involved in consumer product design, (b) extant findings and evidence related to the use of development methods used for the design of consumer products in other industries, and (c) products that have demonstrated success among consumers in regard to adoption and use, and the methods utilized in their development. A second source of data was input provided by a technical expert panel, whose members provided feedback on the design methods and consumer product being reviewed as well as the criteria being used to characterize them (a list of technical expert panel members is included in Appendix A). We developed a classification scheme for the design methods based on a parsimonious set of core characteristics such as degree of structure, iteration, user involvement, and product novelty that supports a higher level of abstraction and facilitates comparisons across methods, and summarized the design methods used for successful digital consumer products. These methods were analyzed to isolate dominant design method characteristics that appear consistently important across different product classes. We drew upon prior research to identify categories of consumer health IT applications, such as those used for information storage, archival, and retrieval or health status monitoring and alternate categorizations of consumer health IT applications. We then juxtaposed and synthesized insights obtained from product design literature, specific, successful design

methods for consumer products, and the particular characteristics of different categories of consumer health IT applications, to recommend particular design methods that may be efficacious for different types of consumer health IT applications.

While the slow diffusion of consumer health IT applications can be attributed to multiple causes, and the success of other digital consumer products is the result of a combination of factors such as marketing, management, and competition, poor design of consumer health IT applications is one significant inhibitor that this report seeks to address. Improved design of consumer health IT applications may promote broader acceptance of these tools and greater extensiveness of use among consumers and move us closer to the desired goal of safer and more cost-efficient health care delivery.

## Findings

The environmental scan identified 18 distinct development methods and 9 broad design approaches, theories, and philosophies. The methods were analyzed and differentiated on the basis of seven characteristics: structure, iteration, span of approach, user involvement, design team composition, novelty of product, and virtualizability. Consumer products were classified into seven product classes: communication; eCommerce; information storage, archival, and retrieval; personalized entertainment; gaming; learning applications; and smart phones. Across these seven product classes, we identified 24 distinct digital consumer products that have exhibited marketplace success.

Our core finding is that, although there is considerable variety in the design methods used for consumer digital products that have been successful, there are common underlying characteristics that, arguably, represent best practices in design. Our analysis further suggests the choice of an appropriate design method is likely to be influenced by the nature of the consumer health IT application, i.e., whether the application is purely digital, such as a Web site or software program, or a hybrid product (an integrated physical device and digital component as a single product from the manufacturer) such as a Nintendo® Wii® gaming system or iPhone smartphone. While many of our recommendations are likely to be effective for all consumer health IT applications, the design needs of hybrid applications are more diverse and warrant additional considerations.

## Design Recommendations

Our research and analysis yields the following set of recommendations:

For designers of all consumer health IT applications—

- Use methods that include high levels of user involvement and iteration. Iterate and involve users early and often.

- Utilize one or more of the following design methods: prototyping; agile development; heuristic evaluation; top-down design; lean product development; and Goals, Operations, Methods, and Selection Rules (GOMS).

- Ensure the design team has medium breadth in regard to team size and the skill-sets represented.
- Engage human factors experts in the design team.
- "Keep it simple" - Choose a parsimonious set of features to include in the application.
- Pay careful attention to user characteristics.

Additional considerations for designers of hybrid consumer health IT applications—

- Use multiple design methods.
- Use prototypes and consumer feedback based on their use of the prototype.

## Future Research and Development Recommendations

We also identify opportunities where the research community can contribute knowledge and help fill gaps in understanding, and areas where the health IT vendor community can assist in accelerating the development of value-adding consumer health IT tools.

## For the Research Community

In addition, we found gaps in current research that need to be addressed to develop a stronger evidence base for the principles and methods underlying effective consumer health IT application design. Additional research is needed in the following areas:

- Systematic comparisons of alternative levels of user involvement and iteration for different types of consumer health IT applications.
- The use of qualitative methods to document and isolate successful and unsuccessful design processes currently in use for consumer health IT applications.
- Case studies retrospectively documenting design processes and longitudinal studies documenting the evolution of market leaders of the four categories of consumer health IT applications discussed in this report.
- Identify contingencies that may affect the efficacy of different design methods for different user populations.
- Investigate user response to products that are modular in nature. Such products would offer increased functionality on a tiered basis so users can select and activate only those specific features that are congruent with their needs.

## For the Vendor Community

Vendors could benefit from sharing information regarding design best practices across the developer community. Industry forums for the dissemination of knowledge related to the design of consumer health IT applications could be a very useful activity.

## Conclusion

The adoption and use of consumer health IT applications may empower patients to manage their health and health care, and improve health care quality. Greater adoption and use may be facilitated by the improved design of consumer health IT applications.

# Chapter 1. Introduction

## Background

Policymakers and researchers have increasingly pointed to the importance of delivering patient-centered care to improve health care quality (Hurley et al. 2009). Leape et al. (2009) argue that one of the core five pillars to improving health care safety is engaging and educating consumers to better manage acute and chronic disease conditions. This has yielded interest in consumer health information technology (IT) applications, designed to support its users in managing their health information and health care (Eysenbach 2000, Krist and Woolf 2011). In contrast to clinical information systems such as electronic health records (EHRs), clinical decision support (CDS), and electronic prescribing that incorporate important functionality for health care providers, consumer health IT applications are targeted toward individuals who receive services from the health care system. They may use such systems to perform a variety of personal health information management (PHIM) and health management activities, including recording and retrieving personal health information, educating themselves about diseases and symptoms by accessing external health information, tracking diet or other wellness activities, and interacting with a community of others who have similar conditions (Agarwal and Khuntia 2009).

Consumer health IT applications offer promise in regard to improving health management (Gibbons et al. 2009), and there is a growing set of products in the market that offer a range of functionality from simple tracking of health-related actions such as food consumption, to Internet-accessible personal health records, to online virtual communities for managing rare diseases. As of September 2010, there were more than 7,000 health applications in the Apple® applications store (App Store), with significant numbers of health applications available for use on Android™ and Blackberry® platforms. Many employer groups, health insurers, health systems, and vendors have been promoting consumer health IT tools for several years, and, in many cases, offer these tools at no cost. Even with this understanding of the potential of consumer health IT applications, an expanding availability of applications, and advocates of the technology who have substantial resources at their disposal for deployment, there is insufficient adoption and diffusion among consumers. There is considerable value to be generated by health IT applications that enable consumers to more easily manage their health and health care. For these reasons there is a clear need to accelerate the development and diffusion of consumer health IT applications that are valued and desired by consumers.

The slow diffusion of consumer health IT applications can be attributed to multiple causes that span the gamut from technical to systemic to social explanations. From a technical perspective, extensive prior work has suggested that an important driver of nonadoption and use of new tools and applications is ineffective and poor design (Dreyfuss 1955, Jimison et al. 2008, Nielsen 1993, Shackel 1991, Shneiderman and Plaisant 2009, Urban and Hauser 1993). Thus, one explanation for the sparse uptake of consumer health IT applications may be that previously found barriers to use remain (Gibbons et al. 2009, Jimison et al. 2008).

Systemic factors that may contribute to low levels of usage include characteristics of the health care system that may not financially reward health care providers for electronic interaction

with patients, the fact that consumers do not typically have easy access to the electronic versions of their clinical records to populate consumer health IT applications, or limited systematic evaluations of tools available in the market that provide evidence for their utility and effectiveness. Social factors constraining widespread consumer health IT adoption include individual characteristics such as computer literacy or technology self-efficacy and consumer concerns about trust and privacy. Further, other factors such as the lack of persuasive marketing or a compelling value proposition may create potential barriers to adoption and use.

This report summarizes research and analysis related to one specific inhibitor of the adoption and use of consumer health IT applications: the design of these tools. As noted above, inferior design is one of several factors responsible for the slow uptake of consumer health IT applications. Broad-based utilization of consumer health IT applications is unlikely to occur unless all the inhibitors are addressed to create a sustaining environment that supports and promotes the use of these tools.

## Purpose and Scope of Report

In 2009 the Agency for Healthcare Research and Quality (AHRQ) convened a workshop to develop key recommendations and an action agenda that would further characterize personal health information management and inform the design of effective consumer health IT systems. Echoing recommendations and evidence found in the research literature, the discussion at the workshop illustrated the importance of the appropriate design of consumer health IT applications as a crucial prerequisite to broad-based diffusion. It was noted that the development of these applications requires a deep and nuanced understanding of the interplay among the user, his/her tasks, tools, the environment, and the context (Wilson and Peterson, 2010). Workshop participants also noted that consumer products in other industries demonstrated success in design, as evidenced by rapid adoption and extensive consumer use. Thus, a key workshop recommendation regarding the improvement of the design of consumer health IT applications was the recognized need for the investigation of the application of design methods and processes used in other industries. The design principles and methods responsible for the success of other consumer products may bear relevance to the successful design of consumer health IT applications.

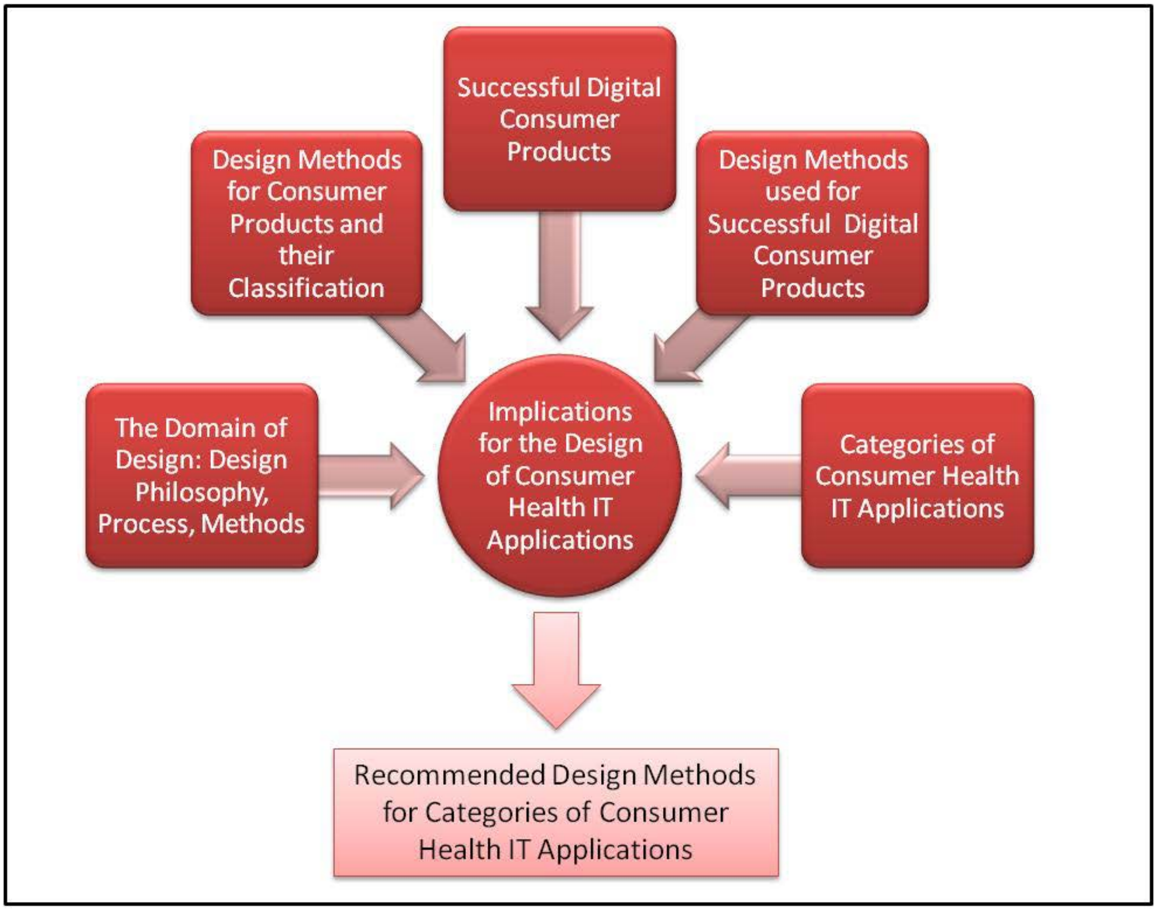
AHRQ commissioned this report as a key deliverable for the task order entitled "Understanding Development Methods from Other Industries to Improve the Design of Consumer Health IT." This task order's findings will provide the foundation for recommendations intended to guide the development of consumer health IT applications. This foundation is critical in order to achieve the desired goal of a patient-centered health care system that is responsive to patient values and needs (Institute of Medicine 2001). This report summarizes and synthesizes findings from an environmental scan and input received from a technical expert panel related to design methods used for the development of successful consumer products in industries other than health care. The broad goals of the report are to inform the design and development of consumer health IT applications. Specifically, the report has the following objectives:

- Present an overview of the domain of design methods, including definitions and descriptions of the core concepts of design philosophy, methods, and processes.
- Identify and analyze the design methods used for the development of successful consumer products.
- Identify dominant design method characteristics that appear consistently across different product classes.
- Extend the design method findings to the design of consumer health IT applications.

The analytic approach utilized for this report is presented in Figure 1. Implications for the design of consumer health IT applications are drawn from an understanding of the domain of design, and a synthesis of findings related to design methods used for consumer products, successful digital consumer products and the design methods used for their development, and prior work on different categories of consumer health IT applications. The implications are then used to develop recommendations regarding the use of specific design methods for different types of health IT products.

The rest of this report is organized as follows. Chapter 2 presents an overview and definitions of the core concepts in the domain of design, including design theories, design process, design methods, and the activities involved in consumer product design. Chapter 3 summarizes the design methods described in prior work, develops a classification scheme for these methods based on a set of common characteristics and categorizes extant methods into this classification scheme. Chapter 4 identifies relevant successful consumer product categories and reports specific products within these categories. We analyze the design methods used for these products to isolate common themes and characteristics, and identify the most commonly used design methods. In Chapter 5 the design method and product findings and analysis are extended to the domain of consumer health IT applications. We also present recommendations for research and for the consumer health IT application design community.

**Figure 1: Analytic approach to recommended design methods**



# Chapter 2. Defining the Domain of Design Methods

## Introduction

The domain of design has been addressed in a variety of literatures including systems development, human factors and ergonomics, human-computer interaction, art and interaction design, marketing, and industrial engineering. Drawing on prior work, we define core concepts and terms that are utilized in this report. We first present the hierarchical structure of design theories and concepts. The discussion outlines and defines the stages in a typical design process, design objects, design method, design methodology, and consumer product design.

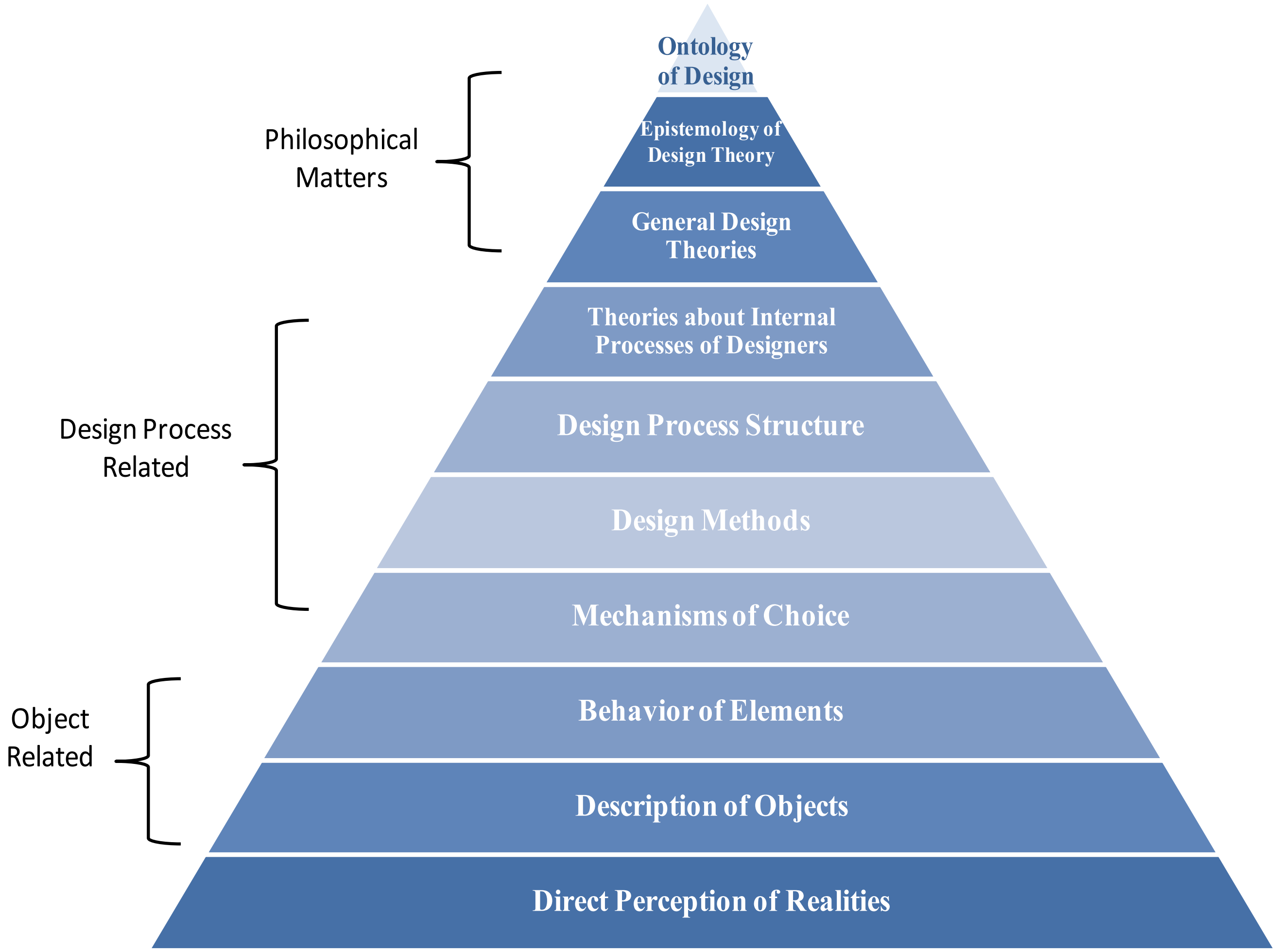
## Design Theories and Concepts

The philosophy of design can be conceptualized as "the pursuit of insights about design by philosophical means," which involves rational reflection rather than empirical observation (Galle 2002). The purpose of the philosophy of design is to help designers understand why they do what they do. Furthermore, the given philosophy a designer adopts guides the approach taken to his or her craft. For example, consider the shift from a design focus on the form of objects to a focus on the use of objects brought about by modernism (Redstrom 2006). A designer focused on the form an object takes might be preoccupied with decorating the object without consideration for the needs of people or society, while a designer focused on designing an object based on how it will be used holds the user's experience and interaction with the object as paramount in design considerations.

Historically, there has been confusion of the terminology and concepts associated with design, and related research has suffered as a result of this ambiguity. While it is not the focus of this report to summarize this debate, establishing a common understanding of relevant definitions used throughout this report is critical to the accurate interpretation of its findings. Recently, researchers have made attempts to provide clarity to design by taking a meta-theoretical approach using a framework that enables concepts to be referenced relative to one another and defining key terms (Love 2002; Ralph and Wand 2009).

Love proposes a hierarchical structure, depicted in Figure 2, that separates design theories and concepts into different levels of abstraction (Love 2002; Love 2000). The lowest level in the hierarchy acknowledges the direct perception of reality. The next two levels within the hierarchy provide theories and concepts that are directly related to design objects. The middle three levels are associated with design methods and processes, while the final three highest levels are associated with philosophical matters. Design methods fall closer to levels associated with design objects in the hierarchy, while design processes fall closer to levels associated with design philosophy in the hierarchy. The 10 levels of this hierarchical structure facilitate a comparison and contrast of theoretical concepts at the appropriate level of abstraction. This report focuses on the levels of the hierarchy associated with design objects, specifically consumer health IT applications and design methods.

**Figure 2: Hierarchy for classifying abstractions of design theory**




## Design Process

Design, when used as a noun, refers to the specification or detailed plan for creating a particular object and is the outcome of the design process (Love 2002; Ralph and Wand 2009). The object may be a system, an artifact, or a process. The outcome of the design process is not always the object itself, but may be a specification for how to create the object. For example, a computer software design specification package is a design for a computer program. Similarly, an architectural blueprint is a design for the construction of a building. The design object may or may not be physical (Ralph and Wand 2009). For the purposes of this report, a design object could be the specifications for an application such as a personal health information management Web site, or an artifact such as a Bluetooth-enabled blood glucose level monitoring device.

The verb form of design is *designing* and refers more specifically to the *design process,* which involves human agents engaging in activities to create a design. Design activities could include the drawing of a diagram, mocking up a Web site in Microsoft® PowerPoint® or sculpting a figure from clay. A designer is a human agent who creates a design by participating in the activities associated with the design process (Love 2002). Although there is no agreed upon set of activities that defines the complete design process, existing literature suggests the

following general series of stages to follow in a typical product design and development cycle (Baxter 1995; Cross 2000; Stoll 1999): preproduction design, design during production, postproduction design feedback for future designs, and redesign.

The *preproduction design* stage subsumes the activities associated with determining the goal of the design prior to analyzing possible design solutions and ultimately detailing a product design specification. Product development ultimately begins with an idea which must be analyzed in terms of the function or functions the product will serve. Once the product design goals have been identified, the potential design solutions can be investigated and analyzed. The design team may seek input from a variety of sources during this stage including but not limited to potential users of the product, past product designs, and similar design solutions in the field. The output of this design stage is a product design specification documenting the requirements of a design solution for the product. The product is built based on the product design specification which makes the gathering of input into the design and documentation of requirements for the product a critically important activity.

The product design specification is then developed and tested as part of a production process. The *design during production* stage refers to the continued refinement of the design solution during the development and testing processes. Unanticipated problems may arise which warrant modifications in the original design.

Once the team is satisfied with the developed product, it will be introduced into its intended environment. At the end of each design effort, the team should summarize the lessons learned so as to improve future design efforts. In addition, results of the effort should be documented. Collectively, these activities are considered to be part of a *postproduction design feedback for future designs* stage.

Finally, any or all stages in the design process can be repeated at any time before, during, or after production. The process of repeating stages in the process is called *redesign*. There may be a number of reasons for repeating some or all of the design stages for a product. For example, there may be a feature that was implemented incorrectly requiring an alteration to the design specification (*preproduction design*) and additional development and testing activities (*design during production*). Alternatively, feedback from users may have provided ideas for new product features. This would require repeating *preproduction design* activities such as the identification of clear design goals for the new features followed by a repetition of the remaining stages in the design process.

The stages listed above are representative of the prototypical design process and, in practice, there may be considerable variation in the specific process utilized. Depending on the product or service, some of these stages may be irrelevant, ignored in real world situations in order to save time, reduce cost, or because they may be redundant in the situation. Further, in each activity there may be several best practices, standards, and methodologies to support or augment the generic stages.

# Design Method

The terms “design process,” “design method,” and “design methodology” are often used interchangeably. However, the process and method or methodology can be distinguished in terms of the level of specificity relative to guiding design activities. Essentially, a design process is broader than a design method because it can include any act or acts of designing along with associated activities, while a method would define a systematic, orderly procedure for attaining an objective (Love 2002). For example, a design process might answer the question, “What are the processes underlying the design of bookshelves?” (Love 2000). A design method for bookshelves would answer the question, “What are the exact steps involved in the design of a bookshelf?” Design methods or methodologies provide a systematic approach to conducting stages of the design process, consisting of guidelines, activities, techniques, and tools (Wynekoop and Russo 1997).

Organizations often must develop new products efficiently and effectively to remain competitive, yet design processes are often complex endeavors requiring tight coordination and planning across business units (Fernandes et al. 2009). In general, design methods are intended to improve design processes to increase the likelihood of successful design outcomes (Kroes 2002). Current design methods are adaptations of earlier design methods, sequential in nature, but modified to reflect environmental complexity and incorporate greater degrees of flexibility. Despite differences in the detailed stages involved and the specific activities to be undertaken, all design methods share the same overarching goal: to provide a “roadmap” to take an amorphous concept and create a marketable product in the shortest amount of time (Fernandes et al. 2009).

# Consumer Product Design

The design process and design methods concepts can be applied to a wide range of artifacts, ranging from industrial products such as airplanes and buildings, to consumer products such as furniture and appliances. This report is targeted at consumer products. In this subsection we describe common issues, challenges, and best practices in consumer product design and common methodologies used in the industry under each phase of the product design process (generally focusing on the preproduction design stage) (Ulrich 2008; Urban and Hauser 1993).

## Identification of Customer Needs

New products targeted at consumer markets generally tend to reflect a “market-pull” type of product, and design process starts with the following activities: (1) identification of customer needs, and (2) measurement of customer preferences. The goal of the first two stages is to understand customer needs and effectively communicate these to the design team. These stages are critical because they ensure that a new product’s focus is on customer needs. The identification process involves identifying latent or hidden needs as well as explicit needs, and developing a fact base for justifying the product specifications. Input from customers is usually in the form of raw data that are interpreted and organized into a needs hierarchy of primary, secondary, and tertiary needs. The relative importance of the different customer needs is also measured. For original products and for new products, the design process is less structured and, for products that are improvements over existing products, more structured data and preference

elicitation processes such as conjoint analysis (Green and Srinivasan 1978) and their extensions (Sawtooth Software 2001) can be employed.

For products representing a "technology-pull" development approach, such as GORE-TEX® rainwear or Tyvek® envelopes, the innovation or product concept originates from the technology team, and the planning phase involves matching technology to markets. In such cases, understanding market needs and preferences comes later. In many product markets characterized by strong retail channels (e.g., Walmart, Home Depot®), the first two stages (identification of needs and preferences) must be supplemented with the retail channel's needs in terms of what types of products would be added to their existing offerings. The retail channel plays a critical role in getting the product to the market successfully, and recent work has focused on developing methods to incorporate such factors (Luo et al. 2007, Williams et al. 2011).

## Developing Product Specifications

Once the customer needs are identified and prioritized, they are translated into technical terms using product specifications that provide a precise description of product performance requirements. The specification targets are set early in the design process and represent the goals and requirements for the design team. These goals and requirements can be refined at the concept generation step where technological and other constraints may need such refinements. Each product specification on a given dimension is a metric that has a nominal (ideal) value and a tolerance around it. Translating customers' needs and requirements into product specifications, including the definition of targets that consider the competitive marketplace, is enabled through a popular technique called House of Quality (Hauser and Clausing 1988). This technique considers the many tradeoffs in customer needs and product specifications in addition to competitive product specifications, if they are available.

The product specifications lead to the development of a product's technical models, which are tools that can predict metric values for a specific set of design-related decisions. The technical models are useful for determining the type of material and technology required to meet the specifications, which form the basis for developing the cost model of the product, that is, how much it would cost to manufacture or produce the product. The product's cost model is developed simultaneously with the technical model, and trade-offs in specifications are considered on a cost basis as specification refinements are made accordingly.

## Concept Generation and Concept Selection

Concept generation follows once the product specifications are developed. The goal of this activity is to thoroughly explore the "space of product concepts" (Ulrich and Eppinger 2008) to develop concepts that address customer needs. Designers may engage in a number of techniques to improve their understanding from the world such as ethnography, market research, product comparisons, and focus groups, which inform their creativity sessions and brainstorming sessions to explore different alternatives. There are a number of structured tools available to support concept generation such as collaborative sketching, IDEO Idea Cards, and functional decomposition (Michalko 1991). While traditionally this stage has been done in-house with designers, recently many open innovation techniques involve entities external to the firm

(e.g., customers, lead users, and channel partners) to help come up with creative concepts (Kornish and Ulrich 2010). Once the concepts are generated, they are analyzed and sequentially eliminated to identify the most promising concept(s). The concept selection process can vary and, in some cases, concepts are scored based on customer/client input or on the specifications of an external entity. In some cases, a product champion may push a concept to the next stage based on his or her influence. Sometimes a decision matrix is used to systematically obtain the individual scores of each design team member for each concept evaluated against decision criteria. In other cases, other formal and informal techniques have been used which include voting on concepts or using group decision support systems to arrive at the consensus choice. Such techniques generally have mixed results in the market (Urban and Hauser 1993). Since a product's ultimate success is significantly dependent on this product development process stage, many researchers recommend systematic customer feedback at this point (Urban and Hauser 1993). Obtaining such feedback generally involves customer concept testing using verbal descriptions or, occasionally, sketches, photos, storyboards, and video.

## Prototypes

For product categories that are more difficult to convey using verbal and other descriptions, designers may develop prototypes for one or more different concepts, depending on budget constraints, and obtain customer feedback for each prototype. Prototypes can take several forms. These may be a fully working prototype or a partially working prototype. Some may be just low fidelity or "mock" prototypes, which do not work, but appear like the finished product. Mock prototypes provide a good indication of product product's "touch" and "feel," and the combination of this information can be used as part of conjoint studies to obtain customer feedback on both objective and subjective product attributes (Luo et al. 2008), even before narrowing down the total concept list. These methods have illustrated a high degree of reliability and validity in formulating predictions of customer preferences (Luo et al. 2008).

## Economic Analysis

Once the product specifications are determined, and the cost model developed for the product, the design team can begin the economic analysis for the new product, which is necessary to justify the continuing product development process beyond the preproduction stage. Many tradeoffs may be considered in this analysis—a tradeoff between development costs and manufacturing costs (from the cost model) on one hand and the product specifications (from the technical model) on the other. Issues of sustainability such as the environmental cost of the product may be factored into the economic analysis. Benchmarking with competitive products is also performed to ensure that the product will be competitive in the market in terms of costs, and that the price point can be supported.

## Other Issues

The details discussed in the preceding activities are common to all consumer product design processes. Since these processes include significant customer feedback throughout the development cycle, they are generally referred to as "customer-driven product design" or "consumer-driven product design" processes. However, there are many instances when a

consumer-driven product design process is not adopted. In the case of technology-push products, for example, the research and development team develops the technology hoping for a market match. However, success of such products is not assured unless the developed technology provides a clear competitive advantage in meeting customer needs, and the available product substitutes are either not available or are of poor quality. In such situations, even when customer input is considered, it may be challenging to consistently meet customer requirements. In addition, many high-technology products are platform-based products where the new product is built around an established technological subsystem. Given the emergence of digital products and products with very short life-cycles, the product development process described above cannot always be followed easily. This has led to variations from the customer-driven approach discussed above with one or more of the following characteristics:

- Varying order of development stages.
- Development stages repeated in an iterative fashion.
- A subset of stages from the design process.

# Chapter 3. Examining Relevant Design Methods

## Introduction

As discussed in Chapter 1, the objective of this report is to understand and recommend appropriate design methods for the development of consumer health IT applications. To accomplish this, we reviewed findings and evidence related to the use of design methods for consumer products in other industries. In total, 18 distinct methods were discovered. The dominant frame we used to identify design methods is based on concepts of industrial design and adopts a utilitarian view of design. We note that aesthetics play an important role in design (Dunne 2005). However, explicit attention to aesthetics is beyond the scope of this report. We distilled the characteristics of each method into a brief description, the stages in the design process in which this method is typically used, the types of industries and/or products for which the method has been utilized, and the method's strengths and weaknesses. To facilitate meaningful comparisons across design methods based on a parsimonious set of characteristics, we developed a classification scheme with seven dimensions for categorizing each design method.

### Why Examine Design Methods From Other Industries?

The past decade has witnessed the transformation of many consumer product industries that have resulted in new ways for people to use digital tools to conduct commerce, engage media, manage information, communicate, learn, play games, and increase their connectivity to the world around them. The proliferation of successful products in these industries has been contingent on design methods and approaches that can effectively identify users' needs and wants, and translate those needs and wants into better products while encouraging a continuous cycle of innovation.

At the same time, the uptake of consumer health IT applications has been relatively stagnant. Health IT product developers struggle to recognize how interdependent factors like demographic characteristics (e.g., age, gender, race, and ethnicity), health status, personal attitudes, and personal health information management strategies and workflow processes are integrated into design methods. Alleviation of this gap may be found through understanding how developers in other industries that have witnessed success are utilizing design strategies.

### Identifying Design Methods

In order to identify the most germane design methods for further analysis, we began with a broad search using Internet searches with Google™ and Google Scholar™ using keywords relevant to our purpose of identifying design methods used to develop consumer products, including terms: product development, consumer products, user-centered design, and product usability. Google Scholar is indexed to the University of Maryland research collection and indexes articles including but not limited to Lexis-Nexis®, EBSCO, ACM Portal, and IEEE Explore databases, which contain both peer-reviewed and grey literature. We also reviewed notable design books including Ulrich 2008 and Verganti 2009. Appendix B lists all search terms and databases used.

Searches yielded numerous sources for building a list of design methods; sources included a variety of conference papers, journal articles, white papers, design tools, and materials from product design consultants. We developed an initial list of design methods to examine in further detail. Members of the technical expert panel vetted the list of 25 design methods, which resulted in the addition of two more design methods.

As indicated in Chapter 2, the use of the terms "design method," "process," and "philosophy" are not consistent throughout the literature. Consequently, it was necessary to closely examine the list of design methods to determine which represented actual methods, based on our definition, and which ones represented design activities at a level of abstraction which was considered too high for our analytical purposes. Of the 27 different methods which were initially identified, the project team in consultation with the Task Order Officer, separated the list into 18 specific design methods and 8 general design approaches, theories, or design philosophies. For example, user-centered design was classified as a philosophy because designing products with consideration for the needs, wants, and limitations of the users serves more as a guiding principle that can include a number of design methods (e.g., slanty design, contextual design) than as a design method with specific guidelines, tasks, tools, and procedures of its own.

It is important to note that while each of the 18 design methods identified are unique, there exist commonalities among certain methods because some are variations of others, or share characteristics, as described in the next section. For example, agile development and scrum both involve iteratively developing software and working with users to prioritize needs. Similarly, since both slanty design and contextual design could be considered variations of the user-centered design philosophy, they extensively involve users, though their methods are not identical.

In order to facilitate the comparison of methods and identification of common themes, Table 1 summarizes the following information:

- Method: Name(s) of the design method.
- Brief Description: Overview of the design method with an emphasis on identifying specific characteristics.
- Relevant Stage(s) in Development Cycle: The phase(s) in the development cycle in which the method is typically used: preproduction design; design during production; postproduction design feedback for future designs; and/or redesign.
- Application Contingencies: Specifies if the method is particularly applicable to a specific industry or product.
- Strengths and Weaknesses: The advantages and disadvantages of using the design method and how best to realize the method's benefits.
- References to publications that describe the methods and their application in product design.

The eight design philosophies, theories, or general approaches that exist at a higher level of abstraction than the specific methods, which were identified by the project team and technical expert panel, are provided for reference in Appendix C. Discussion of the applicability of the most relevant philosophies to the design of consumer health IT applications is provided in Chapter 5.

**Table 1: Descriptions of design methods**

| Design Method | Description | Relevant Stage in Development Cycle | Application Contingencies | Strengths and Weaknesses | References |
|---|---|---|---|---|---|
| Agile Development | An iterative design process that breaks problems into 1 to 4-week "time boxes."<br><br>This method emphasizes—<br>-Individuals and interactions over processes and tools.<br>-Working software over comprehensive documentation.<br>-Customer collaboration over contract negotiation.<br>-Responding to change over following a plan. | All Stages | Used when flexibility is critical and the end point is not known, such as when designs have to remain malleable to customer feedback. With software product design, there are often low costs associated with iterating a finished product. | Strengths: Allows for greater adaptability to user input. Accelerates the delivery of initial business value. Encourages collaboration and quick decisionmaking.<br><br>Weaknesses: Not good for large projects that include more than the 20 team members. Software produced works but is not fail safe – therefore not good for critical systems. | Agile Alliance 2010; Beck 1999; Sliger 2008; Black 2009; Version One 2010 |

**Table 1: Descriptions of design methods (continued)**

| Design Method | Description | Relevant Stage in Development Cycle | Application Contingencies | Strengths and Weaknesses | References |
|---|---|---|---|---|---|
| Collaborative Product Development | An iterative product design method where development professionals are dispersed across different locations, companies, or divisions and use the Internet as a real-time collaboration method.<br><br>Compatible computer aided drafting (CAD), chat and documentation software is often required to facilitate real-time, online collaboration. | Preproduction design, Design during production, and Redesign | Useful in all fields where product design is already performed on computers and several different areas of expertise are required to complete the task. | Strengths: Allows companies with different areas of expertise to work together to solve a potentially larger problem.<br>Design process can generally be done more quickly and with less expense by pooling resources.<br><br>Weaknesses: Creates the potential for loss of control of the design process; half of design partnerships end with unsatisfied partners; potential for uncooperative company partners. | Bruce 1995 |

**Table 1: Descriptions of design methods (continued)**

| Design Method | Description | Relevant Stage in Development Cycle | Application Contingencies | Strengths and Weaknesses | References |
|---|---|---|---|---|---|
| Contextual Design (CD) | Iterative process based on customer input. The process typically involves six steps:<br>(1) Contextual inquiry – Data are gathered from a sample set of users.<br>(2) Interpretation – The data are analyzed to determine how the users behave.<br>(3) Data Consolidation – Designers try to find patterns in the data.<br>(4) Visioning – Cross-functional teams discuss how new products can help the users function.<br>(5) Storyboarding and User Environment Design – The design team describes how. the user will use the product.<br>(6) Prototyping – A model of the product is created to test how users will interact with it. | Preproduction design and Design during production | Useful in all fields where teams are designing for products where users know their needs or desires or at least know when they see what they want. | Strengths: Allows companies to make decisions based on customer perception; provides a common vocabulary and a basis for determining what customers want and their reaction to existing designs.<br><br>Weaknesses: Complex data are difficult to manage and can overwhelm the design team. New product designs may solve only current end users' perceived needs rather than unperceived needs. | Beyer 1998 |

**Table 1: Descriptions of design methods (continued)**

| Design Method | Description | Relevant Stage in Development Cycle | Application Contingencies | Strengths and Weaknesses | References |
|---|---|---|---|---|---|
| Crowdsourcing | Method in which the design is typically based on responses from a call from an organization for solutions to a stated problem; the call is almost always done over the Web and the solution is usually rewarded with money or prestige. | Preproduction design, Design during production, and Redesign | Useful for consumer products, especially in generating new ideas or redesigning a product; requires Web/Internet access. | Strengths: Relatively inexpensive; a solution from the crowd is often better than a solution from one expert.<br><br>Weaknesses: Difficult to control the crowd; crowds are self-selected which may limit diversity of opinions; crowd might rebel and damage the process. | Brabham 2008, Howe 2006 |

**Table 1: Descriptions of design methods (continued)**

| Design Method | Description | Relevant Stage in Development Cycle | Application Contingencies | Strengths and Weaknesses | References |
|---|---|---|---|---|---|
| Focused-Group-Brainstorming | Utilizes groups of people (e.g., members of a company, users of a product) to create a list of possible solutions to a problem. This is a divergent idea generation process.<br><br>Four traditional rules of brainstorming—<br>(1) Don't criticize.<br>(2) Quantity is desirable.<br>(3) Combine and improve suggested ideas.<br>(4) Say all ideas that come to mind, no matter how wild. | Preproduction Design | Useful when organizations have: past and future task interdependence; have past and future social relationships; use the ideas generated; have pertinent technical expertise; have skills that complement other participants; and have expertise in conducting and leading brainstorming sessions. | Strengths:<br>Brainstorming allows individuals and teams to build on each other's ideas and backgrounds.<br><br>Weaknesses:<br>Research suggests that brainstorming groups create fewer nonoverlapping ideas and are therefore less effective than individuals brainstorming independently. | Sutton 1996 |

**Table 1: Descriptions of design methods (continued)**

| Design Method | Description | Relevant Stage in Development Cycle | Application Contingencies | Strengths and Weaknesses | References |
|---|---|---|---|---|---|
| Goals, Operators, Methods, and Selection Rules (GOMS) | Attempts to model a user's interaction with a computer as a series of steps with goals, operators and methods as key variables. **Goals** are what the user intends to accomplish. **Operators** are actions that are performed to get to the goal. **Methods** are sequences of operators that accomplish a goal. Measurements are primarily based on efficiency.<br><br>There are three main variants of the GOMS method: Keystroke-Level Model (KLM);Card, Moran, and Newell GOMS (CMN-GOMS); Natural GOMS Language (NGOMSL). | Preproduction design, Design during production, and Redesign | More commonly used in engineering and human-computer interaction; results may be quantified in terms such as speed or ease of completion. | Strengths: Relatively inexpensive; reduces design errors before expensive user testing.<br><br>Weaknesses: Considers usability and not functionality; it does not address user unpredictability. | John and Kieras 1996; Tonn-Eichstädt 2006; Card et al. 1983 |

**Table 1: Descriptions of design methods (continued)**

| Design Method | Description | Relevant Stage in Development Cycle | Application Contingencies | Strengths and Weaknesses | References |
|---|---|---|---|---|---|
| Heuristic Evaluation | Evaluates an interface against a set of usability design principles; an interface is usually evaluated by a human-computer interaction expert and the product is modified to score higher on the heuristics set. Sample heuristics include:<br>– Visibility of system status.<br>– User control and freedom.<br>– Consistency and standards.<br>– Error prevention.<br>– Flexibility and efficiency of use.<br>– Aesthetic and minimalist design.<br>– Helpfulness to recognize, diagnose, and recover from errors. | All Stages | Most commonly used in engineering and interface design because it can help individuals with technical expertise to anticipate the thinking of novice system users. | Strengths:<br>Inexpensive; intuitive; allows for internal testing; requires little planning.<br><br>Weaknesses: Does not try to reach the ultimate solution, but reaches a good solution; additional design iterations are needed; focuses on problems, not solutions. | Nielsen 1993, Molich and Nielsen 1990, Interaction-Design.org Foundation 2006, Usability.gov 2010 |

**Table 1: Descriptions of design methods (continued)**

| Design Method | Description | Relevant Stage in Development Cycle | Application Contingencies | Strengths and Weaknesses | References |
|---|---|---|---|---|---|
| Lean Product Development | Attempts to remove from product design anything where costs outweigh value to the customer; based on the manufacturing process popularized by Toyota in the 1990's; requires system optimization, redesign of complicated parts, understanding of interaction between parts, and focus on error prevention. Also being used in software development. Steps include the following:<br>(1) Determine customer-defined value.<br>(2) Front-load product development to explore alternative solutions.<br>(3) Utilize rigorous standardization to reduce variation and create predictable outcomes.<br>(4) Balance a team's functional expertise and cross-functional integration.<br>(5) Fully integrate suppliers into system.<br>(6) Use tools for standardization and learning. | Preproduction design, Design during production, and Redesign | Most commonly used in automotive manufacturing; other industries are attempting to adopt it for their own purposes, such as the software industry[1] | Strengths: Creates a less expensive and more reliable product.<br><br>Weaknesses: Difficult to determine the value to the customer for any individual feature, thereby making it difficult to determine which features to remove, which may result in advertently removing certain features that are valued. | Oliver 2006, Mascitelli 2007, Teresko 2007, Morgan 2006 |

[1] Lean product development in the software industry is also called lean software development.

**Table 1: Descriptions of design methods (continued)**

| Design Method | Description | Relevant Stage in Development Cycle | Application Contingencies | Strengths and Weaknesses | References |
|---|---|---|---|---|---|
| Multiple Convergent | Consists of different departments acting independently at different points during a project; information is exchanged between the departments at convergence points so that the various aspects of the project converge toward the stated goal. | Preproduction design and Design during production | Most commonly used when different departments have to interact with each other on projects and must rely on each other's work. | Strengths: Allows iterations among participants within stages; easily accommodates third parties; provides mechanisms for real integration throughout the process among different functions at convergent points.<br><br>Weaknesses: Pieces might not fit together when they are reassembled at the multiple convergent points; developers may experience chaotic feeling until the project converges. | Hart 1994 |

**Table 1: Descriptions of design methods (continued)**

| Design Method | Description | Relevant Stage in Development Cycle | Application Contingencies | Strengths and Weaknesses | References |
|---|---|---|---|---|---|
| Parallel Design | Uses multiple designers independently suggesting a design independently of one another. These designs are then merged to a single unified design that can be more refined through further iterations. A requirements document is needed to ensure that the design groups are given the same information so that design work starts from the same beginning. | Preproduction design and Design during production | Most commonly used in user interface design. Most appropriate when time to market is critical as parallel design reduces traditional iterative processes. | Strengths: Allows a range of ideas to be generated quickly; facilitates several approaches to be explored concurrently; concepts can usually be combined so that the final solution benefits from all ideas put forward.<br><br>Weaknesses: There may be duplicative work; and, resource expenditure for unused designs | Nielsen 1993 |

**Table 1: Descriptions of design methods (continued)**

| Design Method | Description | Relevant Stage in Development Cycle | Application Contingencies | Strengths and Weaknesses | References |
|---|---|---|---|---|---|
| Platform-Based Product Family Design | Attempts to lower the production cost and speed time to market by designing products in order to share components or modules across several products.<br><br>Four general steps—<br>(1) Design requirements and models (e.g., customer requirements, functional requirements, and design constraints).<br>(2) Platform design.<br>(3) Variants design.<br>(4) Platform evaluation, re-negotiation, and iteration. | All Stages | Most commonly used in electronics because off-the-shelf programs can be customized to meet the needs of the user. | <u>Strengths:</u> Sharing components among multiple products reduces the number of items that engineers have to design; increases the quantity ordered of the shared part; lowers cost per product sold; and reduces design time.<br><br><u>Weaknesses:</u> Parts may become more complicated to meet different needs in different products; additional complexity may raise the price per unit or increase the chance of part failure; design limitations may be unjustly placed on the design team, leading to lower-quality products. | Keutzer 2000, Becker 2002, Gonzalez-Zugasti 2000, Bass 2000 |

**Table 1: Descriptions of design methods (continued)**

| Design Method | Description | Relevant Stage in Development Cycle | Application Contingencies | Strengths and Weaknesses | References |
|---|---|---|---|---|---|
| Prototyping | Iterative design process where a sample product is created, tested, discussed, and edited before the process starts over again. The prototype can be critiqued by designers, potential users, project managers, or any number of other groups. | All Stages | It is part of the design process in most industries. Is associated with user-centered design philosophy. | Strengths: Assists companies in making improvements to existing designs and gauging the interest from potential customers; provides an easy way to obtain potential user feedback.<br><br>Weaknesses: Raises costs and extends the design process. | Beynon-Davies 1999 |
| Quality Function Deployment (QFD) | Involves a set of interdisciplinary teams with expertise in areas such as marketing, strategy, engineering, or design. It requires that the teams complete matrices about customer wants and needs. The goal is to foster communication regarding technical and market goals. | All Stages | Most commonly used when different departments are working on the same project. It forces people from different backgrounds to communicate, document their thoughts, and work together. It may be appropriate in later stages of the product design when a series of defined attributes are available for analysis. | Strengths: Has been shown to result in decreases in design costs of up to 60 percent and decrease in design time of up to 40 percent; provides the ability to measure customer satisfaction.<br><br>Weaknesses: Complexity of the matrices limits consideration to approximately eight concepts. | Huertas-García 2009 |

**Table 1: Descriptions of design methods (continued)**

| Design Method | Description | Relevant Stage in Development Cycle | Application Contingencies | Strengths and Weaknesses | References |
|---|---|---|---|---|---|
| Scrum | This is a lightweight management framework and a variation on agile development. The project lead works with his or her team to create a priority list of the needed revisions; design teams are assigned a set of items to complete and begin an intensive 30-day work cycle also known as a "sprint," no other features can be added until the sprint is done, when the sprint is done the priority list should be reevaluated. | All Stages | Often used in the computer software industry because the design work and the coding need to be refined over and over again; computer design can be broken into small independent tasks; and each task can be tested and completed independently. | Strengths: Similar to agile design but it can work for design teams of more than 20 people; allows for planning and forecasting.<br><br>Weaknesses: Not ideal for critical systems; does not produce a failsafe software design. | Schwaber and Beedle 2002; Version One 2010 |

**Table 1: Descriptions of design methods (continued)**

| Design Method | Description | Relevant Stage in Development Cycle | Application Contingencies | Strengths and Weaknesses | References |
|---|---|---|---|---|---|
| Slanty Design | This is an evolution of user-centered design that purposely reduces aspects of functionality or usability.<br><br>Four general steps—<br>(1) Determine how users should optimally use a product.<br>(2) Determine how users are currently using the product.<br>(3) Change the features to make it more convenient for the user to use the product like the producer wants.<br>(4) Test and make sure that the changes are not critical to the customers' continued use. | Preproduction design and Design during production | Commonly used for products such as iPods, Gmail, and physical structures (i.e., buildings); useful when trying to illicit or prevent a certain use of the product. | <u>Strengths:</u> Provides a better user experience by not resulting in a product that includes all possible features; creates positive externalities for the firm. May allow more competitive pricing by virtue of decreased feature set.<br><br><u>Weaknesses:</u> Solutions may be based solely on what is already familiar to the customer and what is currently available. Many customers prefer feature-rich products. | Beale 2007 |

**Table 1: Descriptions of design methods (continued)**

| Design Method | Description | Relevant Stage in Development Cycle | Application Contingencies | Strengths and Weaknesses | References |
|---|---|---|---|---|---|
| Strategy Switching | Based on a designer's thoughts during a project designers record every thought which is then evaluated against the existing design. If the designer's thought does not align with the design, then either the thought is discarded or the design is altered. When all thoughts converge, the design is accepted. | All Stages | Applicable when there isn't a high amount of time pressure. Strategy switching slows down the process, but it also encourages more creative solutions. | Strengths: Allows spontaneous thinking to influence planned thinking and vice versa; divergent method that attempts to create a large number of ideas; may lead to innovative solutions and allow design groups to move beyond expected, safe designs.<br><br>Weaknesses: Method is time-consuming and costly. | Hileman 1998, Jones 1970 |

**Table 1: Descriptions of design methods (continued)**

| Design Method | Description | Relevant Stage in Development Cycle | Application Contingencies | Strengths and Weaknesses | References |
|---|---|---|---|---|---|
| Top-Down Design | Allows users to break a large problem into smaller systems and then subsystems; allows creation of the interface before writing the code; typical steps include the following:<br>(1) Write down the functionality of the system so a clear picture of what it does is obtained.<br>(2) Identify the actors and major components in the system.<br>(3) Group similar tasks or aspects of the program into a single object.<br>(4) For each object, apply top-down functional decomposition. Further break down each of these operations until an "atomic" operation exists with just a few simple programming instructions. | All Stages | Commonly used in computer software design because in computer program design it is easier to break a shared problem into smaller components. The design work can often be done independently of the coding and coding work can be completed in sections. | Strengths: Leads to parallel completion and allows more people to effectively work on a project; provides a cleaner, simpler experience for the end user; parts of the solution may turn out to be more usable; the subsystems can be more focused and less daunting.<br><br>Weaknesses: Design might require an inefficient coding strategy; dividing project into subsystems may lead to communication problems between subsystems. | Boehm 1995, Oliveira 2007, Parr 2009, Stephens 2007 |

**Table 1: Descriptions of design methods (continued)**

| Design Method | Description | Relevant Stage in Development Cycle | Application Contingencies | Strengths and Weaknesses | References |
|---|---|---|---|---|---|
| Waterfall Development | This method follows a set of sequential stages. Once a stage is completed, it cannot be revised (i.e., one cannot go upstream). Stages outlined below are specific to software engineering, but the method can be applied to many different fields. Several variants of this method exist, with slightly different labels for the various stages. In general, the model may be considered as having six distinct steps.<br><br>Typical steps include the following:<br>(1) Requirements analysis and definition.<br>(2) System and software design.<br>(3) Implementation.<br>(4) Testing.<br>(5) Integration and system testing.<br>(6) Operation and maintenance. | All Stages | This design method originated in the manufacturing and construction industries: highly structured physical environments in which latter stage changes are very costly or infeasible. Commonly used in software development where stages flow in order. | <u>Strengths:</u> All of the stages are visible and easy to identify; organizes the design process; follows a logical path.<br><br><u>Weaknesses:</u> Lacks flexibility; difficult to go back up the stages of the waterfall; requires complete problem definition at the beginning of the project; more costly revision process if customer needs change during the project. | Parekh 2005, Royce 1970 |

# Classification Scheme for Design Methods Used in the Consumer Product Market

Given the variety of design methods described in the literature and the considerable overlaps between them, we developed a classification scheme that dissects each method into its constituent parts and supports cross-method comparison. The design methods were classified based on the research team's consensus estimates according to the following characteristics:

- **Structure (low to high):** The structure of a design method specifies the degree of organization and process rigor inherent in the approach. Design methods with low degrees of structure do not have well-defined steps or phases that must be completed in a predefined order. While these types of methods may provide flexibility in the design approach, the lack of structure often makes it more difficult to accurately track the progress of a project. In contrast, design methods with high degrees of structure prescribe well-defined steps or phases that are to be conducted in a predefined order. Tasks are known and project status can be tracked according to the anticipated framework. Design methods with a medium degree of structure have some clearly specified and defined steps, but there may be some flexibility as to which steps may overlap or which steps may be repeated or omitted based on the particular needs of the project.

- **Iteration (low to high):** The iteration associated with a design method refers to the frequency and repetition of changes to the product within the development cycle. Design methods which do not explicitly incorporate iteration as part of the design process but rather prescribe a sequential and nonoverlapping series of steps have low levels of iteration. In contrast, design methods in which iteration is a core and explicitly documented specification in the design process have high levels of iteration. Design methods which may allow for iteration but do not necessarily anticipate numerous cycles fall in between the low and high levels of iteration and were designated 'medium.'

- **Span of approach (single stage to entire development cycle):** Span of approach refers to the degree to which the method is applicable at different stages of the development cycle. Several design methods are intended to support and guide tasks associated with all stages of the development cycle while others are primarily intended to cover specific stages.

- **User involvement (low to high):** User involvement indicates the extent to which the product end user is involved in the development cycle. Low user involvement in the design process is characterized by the user's limited involvement at possibly either the beginning (e.g., during requirements gathering) or end of the project (e.g., during product testing) but not throughout the entire design process. This is in contrast to the high user involvement situation in which users play an integral role in the entire design process beginning with preproduction design through production and redesign. Design methods which involve the user in many of the design phases but not all or involve only a very limited number of users would be considered to have medium user involvement.

- **Design team composition (narrow to broad):** This refers to the variety of skill and expertise involved in the design activities, ranging from a single type of design team member such as a graphic designer (narrow/low) to a multidisciplinary design team (consisting of, for example, usability experts, business owners, project managers, visual designers, information architects, writers, external vendors, developers, researchers, and testers) (broad). A design method requiring a narrow team composition may be executed by a design team consisting of a limited number of different types of skilled members (e.g., primarily usability experts or systems developers). In contrast, a design method requiring a broad team composition is one that consists of a high variety of different types of skilled members (e.g., usability experts, business owners, project managers, visual designers, information architects, writers, external vendors, developers, researchers, and testers); each brings a different perspective and body of knowledge to the project team. A design method which is ideally suited for a moderate number of different types of skilled members (e.g., business owners, information architects, usability experts) has a medium breadth team composition. Cross-functional teams provide significant benefits in new product development including increased access to new information, creativity and innovation (Ancona and Caldwell 1992; Edmondson and Nembhard 2009; Hulsheger et al. 2009), but that must be balanced against the increased communication needs and potential for conflict within the team (Ancona and Caldwell 1992). Medium breadth teams realize the benefits of a diverse team while minimizing the disadvantages.

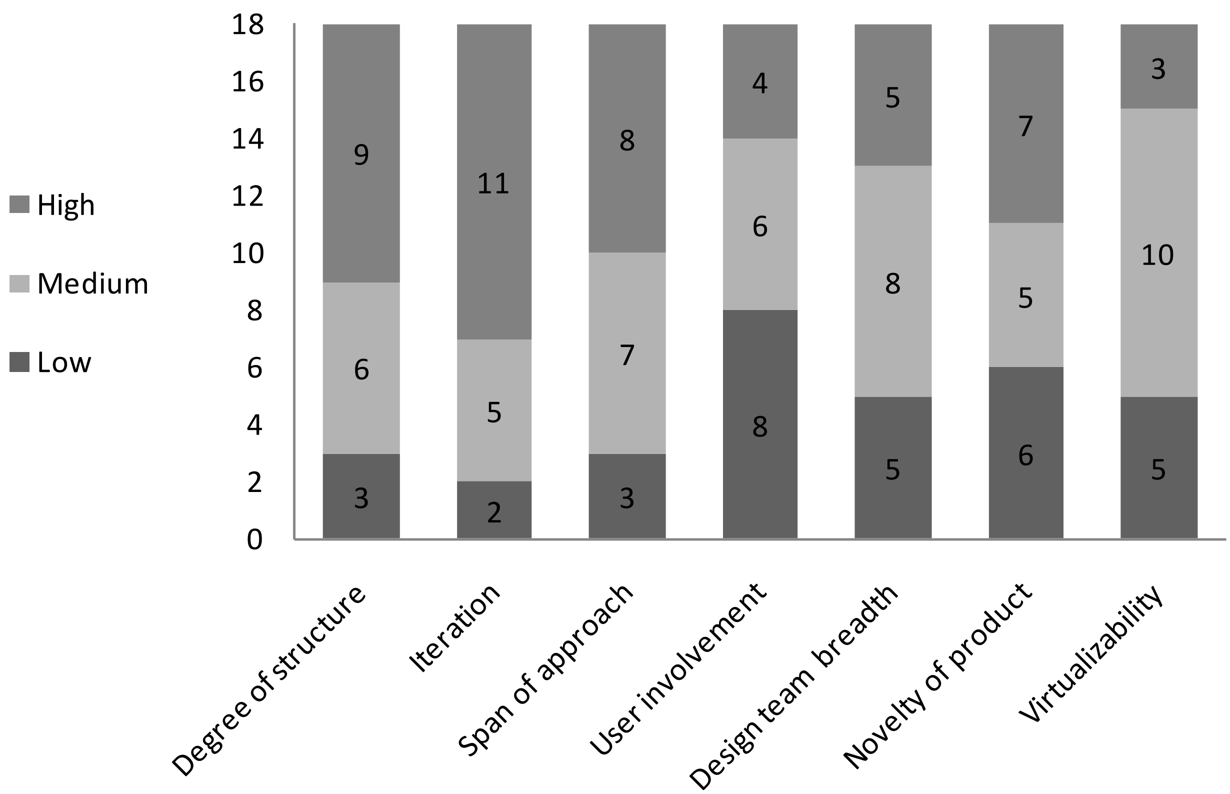
- **Novelty of product (low to high):** This refers to the suitability of the design method for the level of "newness" represented in the product. Design methods range from those more suitable for a product revision (low novelty) to those more appropriate for a radical, new product (high novelty). Incremental changes to existing products may require design processes with less rigor while the creation of innovative new products places higher demands on design methods. Innovative product design requires the generation and application of new ideas or the combination of existing knowledge in unique ways. Design methods for products of medium novelty must support some level of innovation, such as a new feature or set of features, within an existing product.

- **Virtualizability (low to high):** Virtualizability indicates the extent to which the methods may be disaggregated and conducted in virtual or remote environments where the design team interacts through computer-mediated communication. Virtualizability ranges from low—for a method that is not suitable for virtual or remote environments—to high—for methods that may be almost wholly utilized through computer-mediated communication. Studies have shown that the ability to effectively transfer knowledge across team members and build team cohesion is more difficult in a virtual environment (Reed and Knight 2010; Xue et al. 2004). Therefore, design methods requiring high levels of interaction across numerous types of team members with different skill sets, may be more effective when the team is co-located. Such design methods have low levels of virtualizability. In contrast, design methods are highly virtualizable when it is desirable to obtain input from resources that are impossible or infeasible to co-locate for a particular design effort. Design methods with medium levels of virtualizability might be facilitated or constrained by virtualization depending on the specific environmental context within which the method is to be applied.

An example of the classification in the case of the slanty design method follows. The slanty design method is characterized by high levels of iteration and high user involvement and is usually applied in new product development contexts. Slanty design is typically utilized during the early stages of design, including the specification and problem-solving activities common to preproduction. The heuristic evaluation method also applies mostly to the preproduction stage of design and is highly iterative. However, it involves largely internal review and testing by field experts and not extensive testing by users. These methods can both be contrasted with the waterfall method which is highly structured with essentially no iterative steps. User involvement in a heuristic evaluation is low compared to slanty design.

Figure 3 details the frequency and distribution of design methods characteristics across the 18 design methods. For example, the characteristic "Degree of structure" has nine methods exhibiting a high degree of structure, six methods exhibiting a medium degree of structure, and only three methods exhibiting a low degree of structure. The figure shows that, in general, the design methods are evenly dispersed across the characteristics. We note that most design methods are characterized by high to medium levels of iteration; methods are generally applicable across multiple design stages (somewhat broad span of approach); and methods typically entail a medium to high degree of structure. We further note that while in general, across the 18 design methods, eight methods detail a low degree of user involvement, the most frequently used methods detail medium to high user involvement. The design methods used by successful consumer products will be described in Chapter 4.

**Figure 3: Frequency and distribution of design methods characteristics**



# Chapter 4. What We Can Learn From Other Industries' Design Methods

## Introduction

In the last two decades the market has witnessed a surge in consumer products that have experienced unprecedented success in user acceptance and adoption. Examples of such products include eCommerce Web sites such as Amazon.com, entertainment products such as YouTube, and communication products such as Gmail. With the goal of understanding what insights the design of these products offers for consumer health IT applications, we first identified distinct product categories into which successful consumer products could be situated. Within each category, a number of leading products were identified. We explored the design methods used for these products in order to isolate common design themes and patterns that could constitute lessons that may be applicable to the design of consumer health IT applications.

## Identifying Relevant Successful Consumer Product Categories and Specific Products

We developed the following product categories based on a cross-section of the most popular consumer digital goods. Popularity of digital goods was determined based on project team and subject matter expert estimation of the consumer digital product classes exhibiting the most successful diffusion in recent years in terms of number of users and sales.

- Communication (including social networking)
- eCommerce
- Information storage, archival, and retrieval
- Personalized entertainment
- Gaming
- Learning applications
- Smart phones[2]

[2] A smart phone is a mobile phone that offers more advanced computing ability and connectivity than a typical mobile phone and may include, in addition to digital voice, text messaging, e-mail, Web browsing, still and video cameras, music player, and video viewing. Smart phones can run multiple applications, turning the cell phone into a mobile computer (PC Magazine Encyclopedia 2011).

We identified several successful products from each of the product categories. Success was defined based on a product exhibiting high marks in two or more of the following areas:

- Market penetration (based on number of users).
- Sales revenue.
- Accolades in design press.
- User adoption and enjoyment (based on positive product reviews).

Table 2 summarizes the following information about each of the products including the product category, product name, product type (purely digital product that may operate on a variety of platforms or hybrid product incorporating an integrated physical device with a digital component as a single product), description, user characteristics, and design method(s) used. The product type distinction is important because developers of hybrid devices such as the Kindle™ have to consider not only the requirements for the software interface (digital product) but also the ergonomics of the physical device and the context in which it will be used. Developers of purely digital products such as the eBay® Web site are solely concerned with the software design requirements of their digital product. They are not responsible for designing the laptop or smart phone devices through which a consumer might view their Web site.

**Table 2: Successful consumer products relevant to consumer health IT**

| Product Category | Product Name | Product Type | Description | User Characteristics and Acceptance | Design Method | References |
|---|---|---|---|---|---|---|
| Communication | Facebook™ | Digital | Facebook is a social network service where users create a personal profile, add other users as friends, and exchange messages. Users may join common interest user groups. Includes desktop and mobile accessibility options. | Over 500 million people spend 3 billion minutes daily on Facebook to share and connect with the people they care about. | Agile Development, Focused-Group-Brainstorming, Heuristic Evaluation, Lean Product Development | Facebook 2011, Techtree.com 2008, Wroblewski 2009 |
| | Gmail™ | Digital | Gmail is a Web-based e-mail system | Offers the most widely used free online e-mail system. Initial users were younger, wealthier, and more likely to actively use Facebook than the general population. Current users are 33 years old and have higher student debt and mortgage payments than average e-mail client users. | Agile Development, Focused-Group-Brainstorming, GOMS, Incremental Product Design, Platform Based Product Family Design, Prototyping, Slanty Design<br><br>Philosophy:[3]<br>Usability Approach, User Centered Design | Beale 2007, Marketing Vox 2007 |
| | Skype™ | Hybrid | Skype is a voice over Internet provider (VOIP) service. | Largest VOIP vendor. Offers products for consumers and business to facilitate communication and collaboration. | Contextual Design, GOMS, Prototyping,<br><br>Philosophy:<br>Anthropomorphic Approach, Usability Approach | Skype 2011, Voxygen 2010 |

[3] In cases where our research for a given product yielded references to design *approaches, theories and/or philosophies,* we have noted those in addition to design methods. However, this information was not used in the analysis for this report.

**Table 2: Successful consumer products relevant to consumer health IT (continued)**

| Product Category | Product Name | Product Type | Description | User Characteristics and Acceptance | Design Method | References |
|---|---|---|---|---|---|---|
| Communication | Google News™ | Digital | Google News is an automated news aggregator for multiple news sources. | Users like the limited advertisement and diverse content. | Agile Development, Focused-Group-Brainstorming, Platform-Based Product Family Design, Prototyping, Slanty Design<br><br><u>Philosophy</u>:<br>Usability Approach, User-Centered Design | Rodriguez 2003, Sullivan 2010 |

**Table 2: Successful consumer products relevant to consumer health IT (continued)**

| Product Category | Product Name | Product Type | Description | User Characteristics and Acceptance | Design Method | References |
|---|---|---|---|---|---|---|
| eCommerce | Amazon.com® | Digital | Amazon.com is an online retailer for direct and third party sales of consumer goods. | Amazon.com is the largest online retailer, $24.5 billion sales in 2009. Users are predominantly 18 to 49 years old, without young children, and have some education. They are older and more educated users than that of a primary competitor, walmart.com. | Heuristic Evaluation<br><br>Philosophy<br>Anthropomorphic Approach, Usability Approach | McAllister 2010, Tice 2010, Quantcast 2011 |
| | CNET® | Digital | CNET is a Web site focusing on technology product reviews, pricing, downloads, technology videos and news. | Approximately 14 to 17 million people visit CNET every day. Average users are male, 18 to 34 years old, and earning over $100,000 a year. | GOMS, Heuristic Evaluation<br><br>Philosophy:<br>Multiplayer Agent Methods | CNET 2005, Paluch 2008, Quantcast 2011 |
| | eBay® | Digital | eBay is an online auction site where members sell and buy items. | eBay is the most popular online auction site. The average user is over 50 years old with some college background and with an annual salary of between $50,000 and $75,000 a year. | Agile Development, Crowdsourcing, Heuristic Evaluation, Prototyping<br><br>Philosophy:<br>Incremental Product Design, Multiplayer Agent Methods | eBay 2010, Shpanya 2009 |
| | Tripadvisor® | Digital | Tripadvisor is an online collection of reviews and opinions from private travelers to potential travelers. It helps compare travel, hotels, activities and restaurants based on price, location, and user reviews. | With more than 40 million online reviews and more than 40 million monthly visits, Tripadvisor is the largest peer-to-peer travel review site. The majority of those visits are from women over 35 years old. | Crowdsourcing<br><br>Philosophy:<br>User Centered Design | Tripadvisor 2011 |

**Table 2: Successful consumer products relevant to consumer health IT (continued)**

| Product Category | Product Name | Product Type | Description | User Characteristics and Acceptance | Design Method | References |
|---|---|---|---|---|---|---|
| Gaming | Second Life© | Digital | Second Life is a 3D virtual world where users interact online. Users can alter the landscape, create intellectual property, own land, and even schedule meetings. | It was the most popular virtual world, although there has been a significant decline over the last 3 years. Major corporations and developers have been decreasing use. Users are: 58.72% male, 39.21% from the United States (US), 34.51% between 25 and 34 years old, 28.51% between 35 and 44 years old, and 54.1% speak English as their primary game language. | Crowdsourcing, Strategy Switching<br><br><u>Philosophy</u>:<br>Usability Approach | Nino 2010, Borst 2009 |
| | Wii® | Hybrid | Wii is a video game console that includes a motion detection wireless remote controller. | Nintendo has sold 84 million Wii units worldwide. | Heuristic Evaluation, Lean Product Development, Quality Function Deployment, Top-down design (TDD)<br><br><u>Philosophy</u>:<br>Usability Approach, Design Driven Innovation | Deserthat 2009, GameFAQS 2011, VG Charts 2011 |

**Table 2: Successful consumer products relevant to consumer health IT (continued)**

| Product Category | Product Name | Product Type | Description | User Characteristics and Acceptance | Design Method | References |
|---|---|---|---|---|---|---|
| Information Storage, Archival, and Retrieval | Dropbox® | Digital | Dropbox is an online storage system where data is stored using cloud computing and a simple interface. | Dropbox has more than 4 million users and is the leading online storage site. It is predominantly used in the United States by a proportion of Apple computer users that is higher than the national average. | Prototyping, Quality Function Deployment<br><br><u>Philosophy</u>:<br>User-Centered Design | Bodnar 2010, Sharenator 2011, Ying 2009 |
| | Flickr® | Digital | Flickr is an online photograph storage site. Users can organize, backup, and share photos using cloud computing. | In September 2010 Flickr passed 5 billion online photos. On average, users are 27 years old. The users store an average of 1,000 photographs. Forty-four percent of the users are female. | Agile Development<br><br><u>Philosophy</u>:<br>Incremental Product Development, User-Centered Design | Cox et al. 2008, Garrett 2005, Parfeni 2010 |
| | Nike + (iPod - Nike integration)® | Hybrid | Nike + is a pedometer that links a person's shoe to his or her iPod. Running statistics are recorded and can be shared via the Web or used in competitions. | Nike wants to obtain 15% of all runners as clients (i.e., 15 million people). In the first 3 months, Nike sold 450,000 units, mostly to men 18 to 40 years old. By the end of the first year, Nike had sold 3 million units. | Heuristic Evaluation, Lean Product Development<br><br><u>Philosophy</u>:<br>User-Centered Design | Business Week 2005, Holmes 2005 |

**Table 2: Successful consumer products relevant to consumer health IT (continued)**

| Product Category | Product Name | Product Type | Description | User Characteristics and Acceptance | Design Method | References |
|---|---|---|---|---|---|---|
| Information Storage, Archival, and Retrieval | PatientsLikeMe® | Digital | PatientsLikeMe is an online medical community where people share their experiences, symptoms and thoughts about chronic life altering diseases in order to track and learn from other people's real life experiences. | The site includes 19 disease-specific areas. Participation has been very high for many diseases. For instance a large number of newly diagnosed Lou Gehrig's Disease and multiple sclerosis patients in the United States have joined. There are currently 20,000 multiple sclerosis patient users. | Heuristic Evaluation, Top-Down Design<br><br>Philosophy:<br>Cognitive Approach | PatientsLikeMe 2011, Frontline 2007 |
| | Quicken® | Digital | Quicken is an online and a computer-based financial management software. It helps individuals and small businesses manage their financial expenditures and set financial goals. | Ten million people use Quicken. Over 4 million people use Mint.com, which was purchased by Quicken in 2009 and serves as Quicken's free online service. Quicken users typically are in higher income brackets than the general population, have university degrees, and are actively involved in investing. | Quality Function Deployment, Top-Down Design<br><br>Philosophy:<br>Usability Approach | Intuit 2007, Fast Company 2010, Small Business Online Community 2010 |
| Learning Applications | Blackboard® | Digital | Blackboard software is used to manage e-learning, and has been extended to transaction processing, eCommerce, and online communities. | Blackboard is the predominant e-learning application. It is not a direct-to-consumer product but is used by consumers to manage online learning; arguably consumers have little choice in their platform, but there are multiple options in the market. | Prototyping<br><br>Philosophy:<br>Usability Approach | Fay 2008 |

**Table 2: Successful consumer products relevant to consumer health IT (continued)**

| Product Category | Product Name | Product Type | Description | User Characteristics and Acceptance | Design Method | References |
|---|---|---|---|---|---|---|
| Personalized Entertainment | iPod shuffle® | Hybrid | iPod shuffle is a small flash-based, screenless, durable, digital music player that holds a limited number of songs and has minimal features. | Apple has sold millions of iPod shuffles and it is the top seller in the flash based digital media player market. iPod shuffle competes at a much lower price than Apple's related product, the iPod Touch. Users like that the iPod shuffle is easy to use, comparatively inexpensive, and durable. | Agile Development, Crowdsourcing, Focused-Group-Brainstorming, GOMS, Heuristic Evaluation, Platform Based Product Family Design, Prototyping, Slanty Design, Top-Down Design<br><br>Philosophy:<br>Usability Approach, User-Centered Design | Beale 2007, CNET 2005, Thompson 2005 |

**Table 2: Successful consumer products relevant to consumer health IT (continued)**

| Product Category | Product Name | Product Type | Description | User Characteristics and Acceptance | Design Method | References |
|---|---|---|---|---|---|---|
| Personalized Entertainment | Kindle™ | Hybrid | Amazon's Kindle is a portable electronic book (e-book) reader. It is a software, hardware, and network platform that utilizes wireless connectivity to enable users to shop for, download, browse, and read e-books, newspapers, magazines, blogs, and other digital media. | The Kindle is the most popular e-book reader. Amazon has sold millions of units and now sells more e-books than paper books. The Kindle reaches a different segment of the market than traditional online sales. The average age of a Kindle owner is 50 to 59 years old. | Agile development, Learn Product Development, Slanty Design<br><br>Philosophy:<br>Usability Approach, User-Centered Design | Gratt 2010, Faas 2011. Lab126 2011, Peters 2009 |
| | Netflix® | Hybrid | Netflix is a DVD rental and streaming video company. | Netflix is the leader in online video streaming and DVD rental through the mail. It is projected to have reached 18 million customers by the end of 2010, with 60% of its users streaming content. The average user is over 35 years old, female, and earns less than $75,000 annually. | Agile development<br><br>Philosophy:<br>Usability Approach, User-Centered Design | Porter 2006, Siegler 2010, Mullaney 2006 |
| | Pandora® | Digital | Pandora is a digital streaming radio station that creates individual content based on users' preferences and song rating. | Pandora has 48 million users making it one the most popular streaming radio stations. While users average 11.6 hours a month, this is less than the 52 hours an average broadcast radio consumer listens each month. The average user is 18 to 34 years old and male. | Agile development, Slanty Design, TDD<br><br>Philosophy:<br>User-Centered Design, | Miller 2010, Watts 2009, Link 2009 |

**Table 2: Successful consumer products relevant to consumer health IT (continued)**

| Product Category | Product Name | Product Type | Description | User Characteristics and Acceptance | Design Method | References |
|---|---|---|---|---|---|---|
| Personalized Entertainment | Slingbox® | Hybrid | Slingbox allows users to connect to and watch their home TVs from a mobile device. | The most recent Slingbox design won a "Gold Award" and the "Best in Show" at the 2010 Industrial Designers Excellence Awards. Slingbox.com has 120,000 daily visits, of which 61% are from the United States. Typical users are 25 to 44 years old. | Contextual Design, GOMS, Lean Product Development, Prototyping<br><br>Philosophy:<br>User-Centered Design | Ritke 2011, Sharenator 2011 |
| | TiVo® | Hybrid | TiVo is a digital video recorder (DVR) which allows users to record television programming. | TiVo was one of the first DVRs and it was very successful for several years. However, recently TiVo's sales have fallen. | Collaborative Product Development, Heuristic Evaluation, Prototyping, Quality Function Deployment<br><br>Philosophy:<br>Usability Approach | Burns 2010, Nielsen 2008 |
| | YouTube® | Digital | YouTube is an online storage site for videos. It allows users to watch and share their home videos. | YouTube is the industry leader for online videos with more than 2 billion views per day. YouTube earned a 41.9% share of videos viewed on the Internet in the U.S. and as of May 2010 exceeds 2 billion page views per day. | Contextual Design, Heuristic, Lean Product Development, TDD | Lowensohn 2010, Metekohy 2010, Parr 2009, Rao 2010, Whitney 2011 |

**Table 2: Successful consumer products relevant to consumer health IT (continued)**

| Product Category | Product Name | Product Type | Description | User Characteristics and Acceptance | Design Method | References |
|---|---|---|---|---|---|---|
| Smart Phone | iPhone® | Hybrid | The iPhone is a smart phone. | Approximately half of iPhone users are under the age of 30 and approximately 15% are students. At least 75% of US iPhone users are previous Apple customers who used either iPods or Macintosh computers, suggesting that Apple builds brand loyalty. | Focused Group Brainstorming, GOMS, Platform-Based Product Family Design, Prototyping, TDD<br><br>Philosophy:<br>Cognitive Approach, Usability Approach, User-Centered Design | Claburn 2007, Rubicon 2008, Walters 2008 |

# Identifying Design Methods Used for Development of Successful Products

For each of the relevant, successful consumer products identified, it was necessary to determine the design methods used by each organization in the product's development prior to identifying common design method themes across the products. This process involved Internet searches on Google® and Google Scholar™ using the product name in combination with keywords related to design (e.g., design, development, and user profile). Searches yielded a variety of sources including company and individual Weblogs, news articles featuring interviews with company employees, books, online news magazines, and journal articles. Appendix B lists all search terms and databases used.

Two challenges arose during the process of identifying product design methods. First, as might be expected, organizations that develop successful products closely guard information about their design and development activities. As a result, there were limited references to specific design methods employed for a few products. In these circumstances, trade press articles containing anecdotal stories about design team and user interactions provided insight, and articles featuring interviews with the organizations' designers provided general design philosophy information from which design methods could be inferred.

Second, the design method terminology used throughout the literature and used to develop specific, successful consumer products was not necessarily consistent with the literature on design methods. Occasionally, the method used by the organization itself was not identified but rather the steps involved in the design process were described. In other cases, the organization may have referred to the method using an internal name. For the sake of clarity, we consistently used the design method names from Table 1 to indicate the methods used for each product listed in Table 2. Multiple design methods are listed for products if the organization employed more than one method during the product's development. Design philosophies are also noted for products when these were discovered during the analysis and refinement of design methods.

## Product Findings

In this section we present findings related to the design of successful consumer products. In particular, we explore relationships among the characteristics of the dominant design methods used by the developers of these successful products. Our objective in the analysis was to isolate design characteristics along which successful products could be reasonably classified.

Of the seven features used to characterize design methods in Table 1, two stood out as potentially important given recent trends in product development. First, increasingly, design teams are designing products with the user experience as the focus of their efforts which is consistent with the “market-pull” approach described in Chapter 2 (Redstrom 2006). Second, development methodologies incorporating iteration are on the rise due to the increasing need to respond to rapid changes in the market environment (Knipp 2010; Knipp 2011). Figure 4 depicts the design methods summarized in Table 1 along these two dimensions/characteristics. The majority of the design methods appear on the right side of the figure suggesting that they involve high levels of iteration. Many of the design methods are further clustered in the top right of the figure because they are also exemplified by high levels of user involvement. However, this graph by itself is not very insightful as it does not combine information about the successful products that use these design methods.

Plotting the successful products on the same two dimensional graphs based on the design methods used in their development yielded interesting insights when using the product type designations. Specifically, we observed two distinct product clusters: (1) purely digital products utilize design methods characterized by high user involvement and high levels of iteration and (2) hybrid products (products consisting of a combination of a physical device and a digital product) utilize multiple design methods including methods characterized by high user involvement and high levels of iteration and others. Plotting the products along these two dimensions, based on their product category, yielded no significant findings in terms of the design methods employed across product categories. That is, organizations developing eCommerce products versus information storage, archival, and retrieval products do not use consistently different or unique numbers of methods (see Appendix D).

**Figure 4: Design methods by degree of user involvement and iteration**

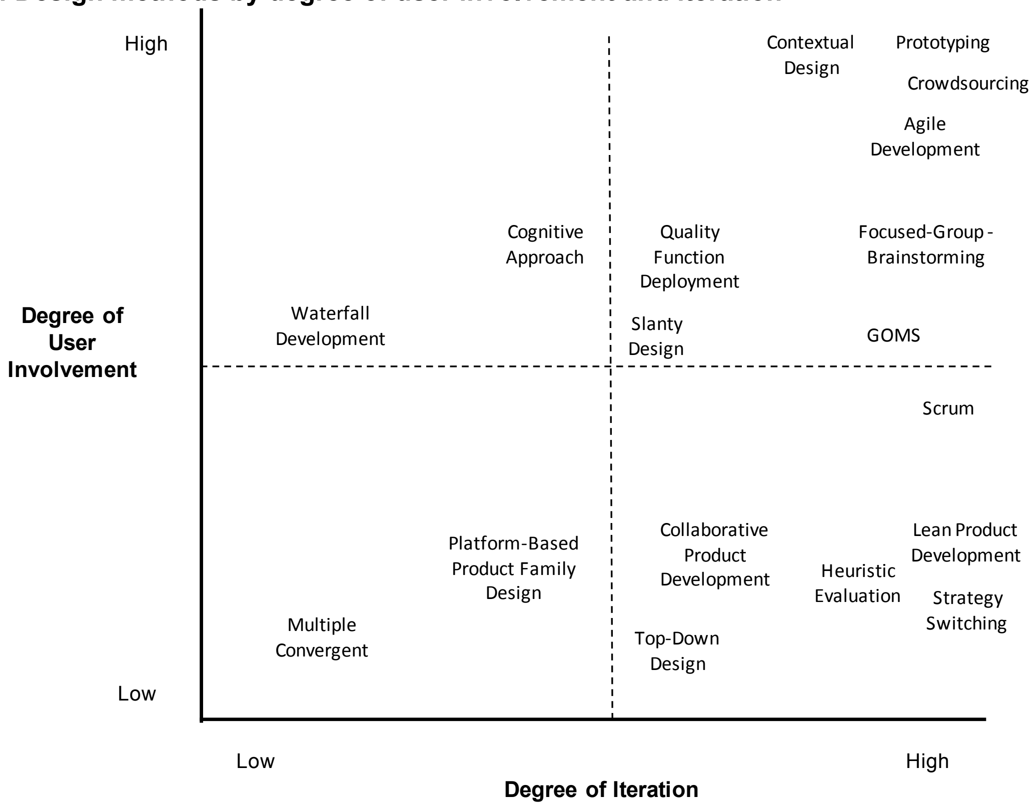
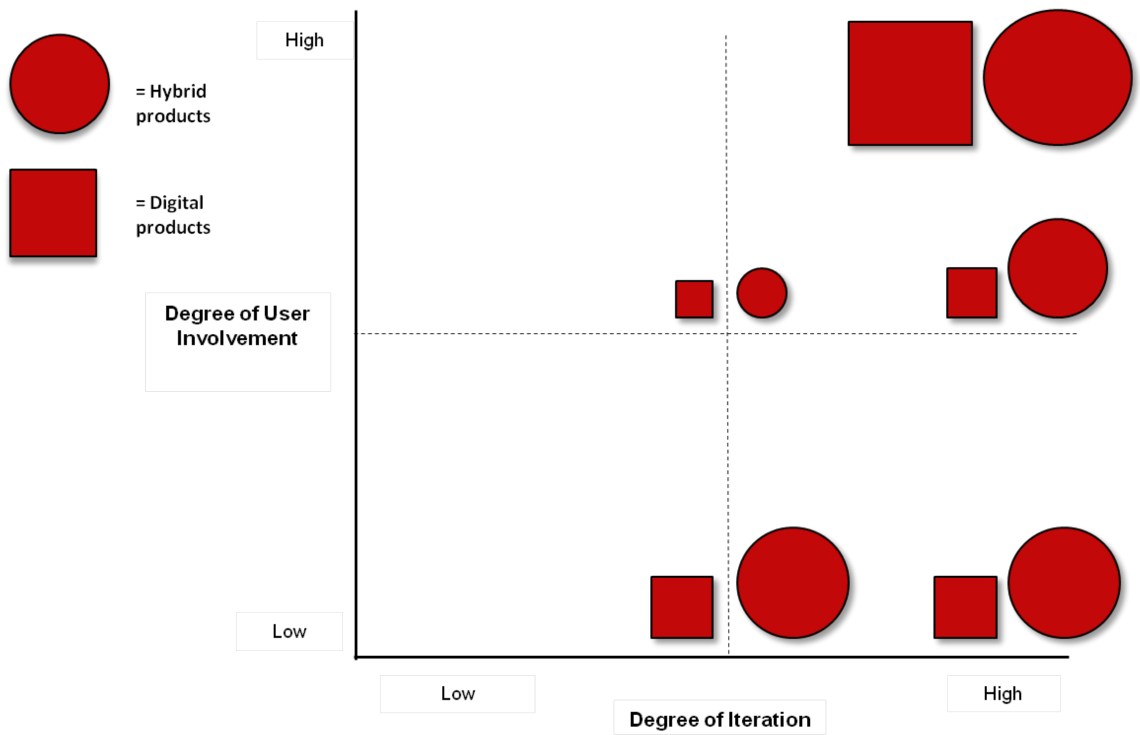



Figure 5 depicts the prevalence of utilized design methods based on degree of user involvement and user iteration among hybrid and purely digital successful consumer products, respectively. Hybrid products are represented as circles and digital as squares. There are multiple circles and squares in different regions of the graph because each product uses multiple methods; the respective methods are located at different degrees of user involvement and degree of iteration. The size of the shape approximates the frequency of the method used, e.g., the circle is approximately twice as large as the square in the “high degree of iteration” and “low degree of user involvement” area because the hybrid products reviewed use design methods that exhibit, on average, “high degree of iteration” and “low degree of user involvement” in approximately twice the frequency than digital products. The hybrid products and digital products make use approximately equally of methods using a “high degree of iteration” and “high degree of user involvement,” and in greater proportion than methods located elsewhere on the graph.

**Figure 5: Successful consumer products classified as digital/hybrid by degree of user involvement and degree of user iteration of design methods**




A significant majority of the successful consumer products (75%) were developed using design methods characterized as having high levels of both user involvement and iteration. For example, to highlight the importance of user involvement at Facebook™, the motto, "share early and share often" is a guideline (Wroblewski 2009, p. 1). At TiVo®, the company involves users in developing their electronic remote control devices and their Web site content. In addition, based on user testing, TiVo designers have changed not just the Web site content but also its presentation. TiVo believes that by involving users early in the design process, problems can be avoided that would not otherwise be found until after implementation (Nielsen 2008). Involving users in the product design cycle may be more costly in the short run and takes longer, but making use of customer interaction in the design process increases a product's chances of meeting the customer's needs (Abras 2004).

The organizations developing these highly successful consumer products consistently utilize methods with high levels of iteration, underscoring that good design is an evolutionary process and that products themselves will be continually changing to respond to changing consumer preferences. The designers at Netflix® believe in quick iterations and update their Web site as often as every 2 weeks (Porter 2006). They anticipate some changes will be successful while others will fail. Netflix believes that with frequent changes, failures are less expensive. At Facebook, they stress to designers the dangers of "falling in love" with specific software functionality because it is impermanent and destined to change (Wroblewski 2009). Advertisements placed for open software designer positions at PatientsLikeMe® specify that applicants must have a background in scrum, a derivation of the agile development design method, which involves frequent releases of the product with additional features. The importance

of prototyping in the iteration process is supported in the literature. Enabling consumers to use the product and provide feedback into the design process, rather than simply conducting interviews or focus groups, aids the determination of the functionality that users value in a product or service (Rust et al. 2006).

While many of the individual, successful consumer products listed in Table 2 were developed using more than one design method, and Figure 4 indicates that both digital and hybrid consumer products are developed using a variety of methods, we note that hybrid products utilize multiple methods to the greatest extent. Figure 6 presents the average number of design methods by product type, while Figure 7 presents the average number of design methods by product category. On average, hybrid products use almost 65 percent more design methods than purely digital products, with hybrid products using 4.4 methods compared to approximately 2.6 methods for purely digital products. The average number of design methods used across all products is 3.2 design methods. The smart phones category, a product category consisting entirely of hybrid products, exhibited the greatest usage of different methods at six methods. The product that exhibited the greatest usage of different methods was the iPod shuffle, with nine methods used.

**Figure 6: Average number of design methods used by product type**

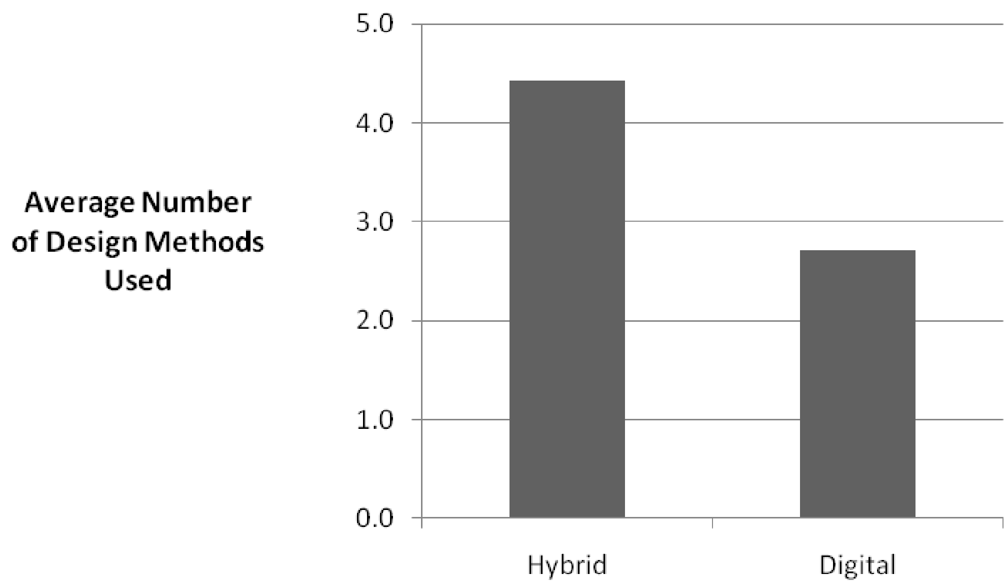
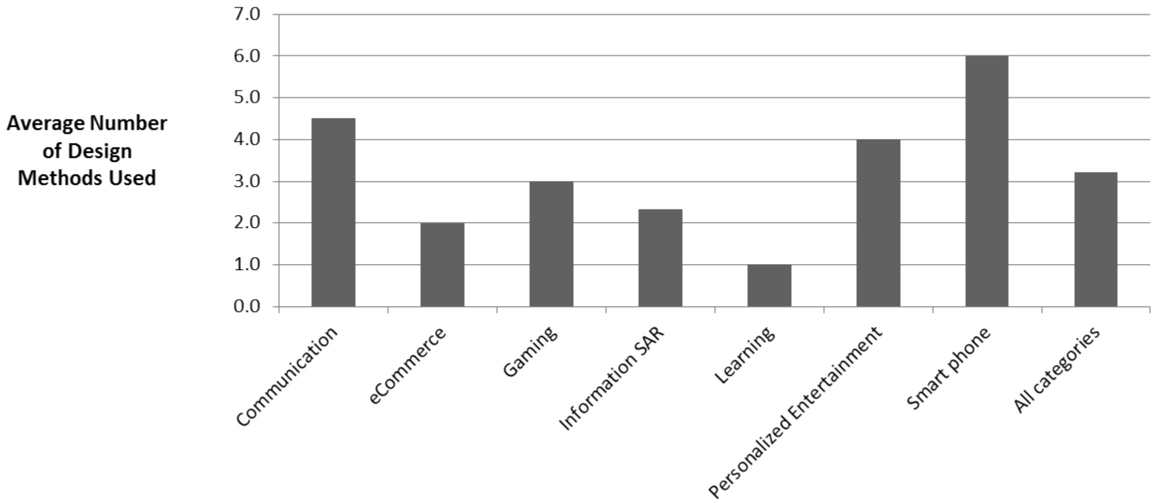


**Figure 7: Average number of design methods used by product category**

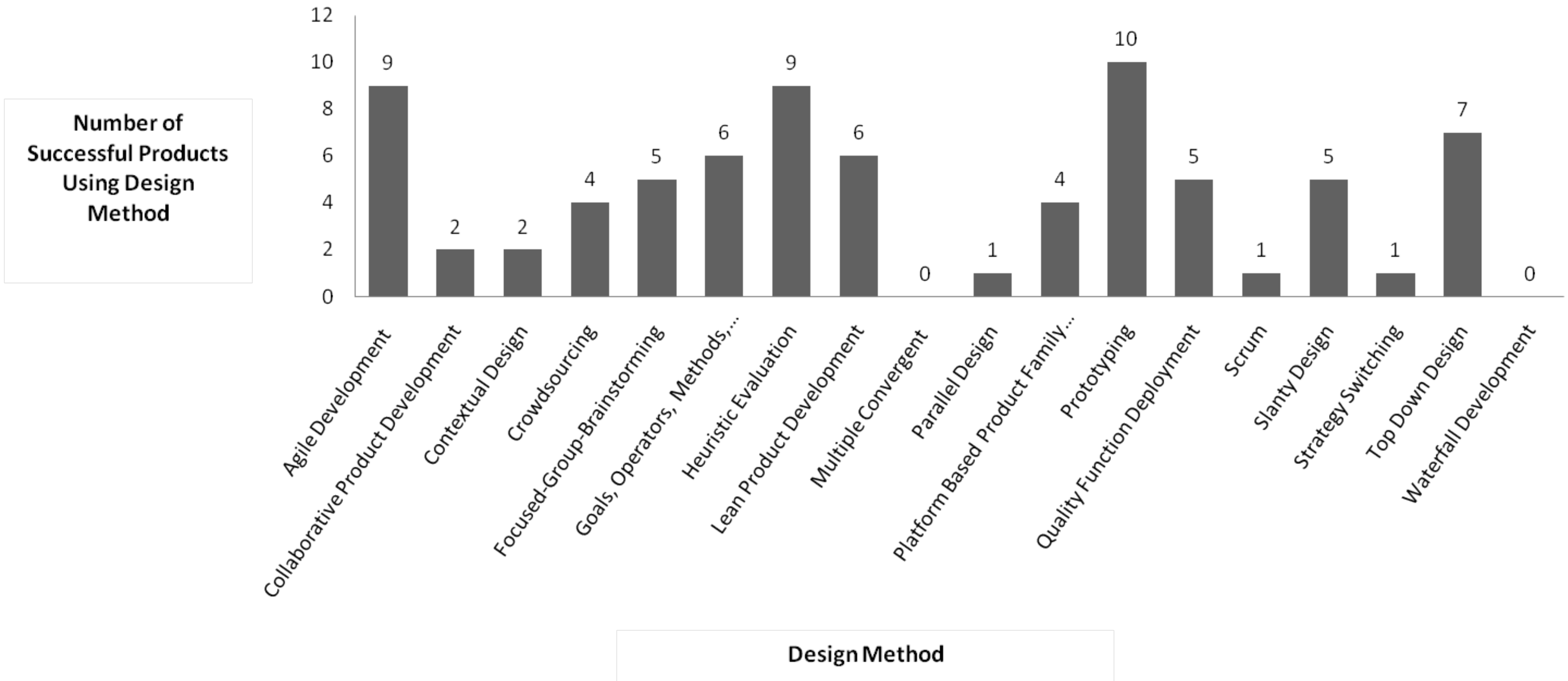



In addition to the interpretations based on the analysis of commonalities across design methods identified in Table 1, our literature scan suggests that many of the organizations developing these successful consumer products approach design with an attention to the number of features incorporated into their products.

Many of the products included in this study tended to be streamlined and simple, at least at the user interface level, and not loaded with too many features that may overwhelm the user. For example, when designing the Facebook application's mobile version, designers focused on only the key features likely to be required by users "on the go," such as updating their status. This is consistent with Facebook's goal of keeping the user interface clean and simple (Wroblewski 2009). Apple® used the slanty design method to design its iPod shuffle. Google also espouses the importance of building in "only the features that people need to accomplish their goals" as a theme across their product portfolio (Google 2010). Studies have shown that although consumers are often drawn to products with numerous capabilities, they are dissatisfied when having to figure out how to actually use them (Rust et al. 2006; Thompson et al. 2005). Thus, it is wise for designers to mask underlying product complexity and develop interfaces that are simple, and perhaps customizable so that added features can be revealed based on the user's preferences. For example, a particular application menu may support 10 different functions. If a user only requires three of those functions, the interface should be flexible enough to permit hiding the rest (Kang 2007).

Figure 8 summarizes the frequency of use of the 18 design methods across the 24 successful consumer design products reviewed. There are several methods which were described in the design method literature, but were not used according to the product findings, such as multiple convergent, scrum and waterfall development.

**Figure 8: Design method usage by successful products**



The top six most frequently used design methods by the successful products include: prototyping, agile development, heuristic evaluation, top-down design, lean product development, and GOMS. Table 3 details the frequency of the top six design methods used by the reviewed products, in order of frequency, along with the design method's respective degree of user involvement and degree of iteration. The two most frequently used methods involve both a high degree of user involvement and a high degree of user iteration. The level of iteration across all six most frequently used products was high or medium. The level of user involvement across the most frequently used products exhibit greater diversity and is generally spread evenly. A commonality across the top three methods is that the breadth of the design team is rated medium, suggesting there is a balance between too little a diversity of skill and an overly complex group of design team participants.

**Table 3: Most frequently used methods by reviewed products**

| Design Method | Percentage of Reviewed Products Using Method | Number of Reviewed Products Using Method | Degree of User Involvement | Degree of Iteration |
|---|---|---|---|---|
| Prototyping | 42% | 10 | High | High |
| Agile Development | 38% | 9 | High | High |
| Heuristic Evaluation | 38% | 9 | Low | High |
| Top-Down Design | 29% | 7 | Low | Medium |
| Lean Product Development | 25% | 6 | Low | High |
| GOMS | 25% | 6 | Medium | High |

Of note is that the most frequently used design philosophies used across the reviewed products were user-centered design and usability approach, with half of all products using one or both of these philosophies. These philosophies incorporate user input early in the design and evaluation, and product development activities are guided by focusing on the user's experience and needs.

# Chapter 5. Extensibility of Design Approach Findings to Consumer Health IT Applications

## Introduction

Chapter 4 identified seven categories of successful consumer products that are likely to be relevant for the design of consumer health IT applications and detailed the design methods used for specific instances of exemplar products in each category. We mapped the frequency of use of each of the design methods described in Chapter 3 (summarized in Table 1) across the entire set of successful products, as well as the number of methods used in the development of products represented in each consumer product category. In this chapter we integrate and synthesize the findings. We begin by describing extant classifications of consumer health information technology (IT) applications based on the user tasks and functions they support. Next, we discuss how the design method and consumer product findings may be applicable to the design of these systems. The chapter concludes with a set of recommendations for the future. Recommendations for consumer health IT application design are based on our assessment of consumer product design practices from other industries.

## Consumer Health IT Applications

In general, consumer health IT applications are tools and artifacts that use information systems to support an individual [consumer] in the management of his or her health-related needs. Gibbons et al. (2009) note there is no universally accepted definition of such tools in the literature. For the purposes of this report, we use the definition provided by Gibbons et al. (2009, p. 13) who define consumer health informatics applications as:

"Any electronic tool, technology, or system that is

- Primarily designed to interact with health information users or consumers (anyone who seeks or uses health care information for nonprofessional work).
- Interacts directly with the consumer who provides personal health information to the consumer health informatics (CHI) system and receives personalized health information from the tool application or system."

However, we do not exclude consumer health IT applications that may be used with a health care professional.

Recent literature has described classifications of consumer health IT applications and has identified individual applications. Jimison et al.'s (2008) review of *interactive* consumer health IT applications specifies six distinct application types.

1. In-home monitoring, disease management, and self-management systems.
2. Online forums on health topics.
3. Electronic patient access to their medical records and patient-physician electronic messaging.
4. Interactive educational system used once or sporadically.
5. Interactive training systems that monitor patient signals and provide immediate feedback.
6. Interactive and tailored reminder systems.

Further, examples of noninteractive consumer health IT applications may include but are not limited to general health information Web sites without a forum, such as WebMD®, that provide access to information about diseases, symptoms, and other health related issues; or systems that give patients electronic access to their medical records without any interactive functionality.

In a comprehensive study that surveyed and summarized the state of the art in personal health information management, Agarwal and Khuntia (2009) describe four distinctive categories of tools and artifacts, listed below, that each support specific personal health information management tasks.

- **Health information storage, archival, and retrieval.** This category includes tools that directly help in the functions of storage, archival, and retrieval of personal health information.
- **Health status monitoring.** This category of artifacts includes systems and tools for assessing and monitoring the users' health status and/or monitoring specific health conditions. Here we include only tools that have a built-in information management and storage component. Thus, a device that solely aids in measuring a specific health indicator such as blood pressure is excluded.
- **Health information seeking and searching.** This category includes tools that directly help in the functions of seeking and searching for health-related information.
- **Infrastructural tools and artifacts.** This category of tools and artifacts consists of emerging devices, applications, and design concepts that constitute the foundations for specific consumer health IT applications. For instance, researchers have developed clinical database architectures and algorithms for facilitating information search and retrieval processes in electronic repositories which have been implemented in many of the artifacts described here.

We use the classification developed by Agarwal and Khuntia (2009) because it is the broadest and most comprehensive of alternative classifications and is constructed at a higher level of abstraction.

We note that Jimision et al.'s (2008) classification can be mapped onto Agarwal and Khuntia's (2009) as follows in Table 4.

**Table 4: Mapping of consumer health IT application classifications**

| Jimision et al. Category | Agarwal and Khuntia Category |
|---|---|
| In-home monitoring, disease management, and self-management systems. | Applications that support health status monitoring |
| Online forums on health topics. | Applications for health information seeking and searching |
| Electronic patient access to their medical records and patient-physician electronic messaging. | Applications for information storage, archival, and retrieval |
| Interactive educational system used once or sporadically. | Applications for health information seeking and searching[4] |
| Interactive training systems that monitor patient signals and provide immediate feedback. | Applications that support health status monitoring |
| Interactive and tailored reminder systems. | Applications that support health status monitoring |

It is clear from the discussion above that, much like what is observed in the consumer product space, there is considerable variety in the types of products comprising consumer health IT applications. Each type of application provides a distinctive set of functionalities supporting specific aspects of a consumer's personal health information management and health management activities. Consumer health IT applications that are in the categories of health information seeking and searching, health information storage, archival, and retrieval are predominantly digital in nature. Examples here include electronic patient access to his or her medical records, educational systems, and online health Web sites offering information and education about a range of health-related issues. Consumer health IT applications supporting health status monitoring or belonging to the category of infrastructural tools and artifacts may be digital or hybrid depending on how they are designed. It is also important to point out that hybrid products may be designed for other categories of consumer health IT applications as well. For example, health information storage, archival, and retrieval could plausibly be performed using a special purpose hand-held device, much like the iPod in concept. To the degree the type of design method selected should be driven by what the tool is supposed to do for the user, and the digital or hybrid nature of the product, different design methods are likely to be more efficacious across different types of consumer health IT applications.

# Recommended Design Methods for Categories of Consumer Health IT Applications

Our analysis and classification of the successful product design methods juxtaposed with the specific types of consumer health IT applications discussed in the above section provides some useful insights into the relative strengths of alternative design methods. We offer the following recommendations for the design of consumer health IT applications.

[4] It is important to point out that interactive educational systems do not correspond completely to applications for health information seeking and searching; as the latter may or may not include an instructional component.

***Recommendations for Designing all Categories of Consumer Health IT Applications.*** Our findings across the entire set of 24 successful consumer products and the design methods utilized in their development pointed to a handful of methods (6) that dominate in their frequency of use for the development of successful consumer products. These methods are, in order of frequency of use: prototyping, agile development, heuristic evaluation, top-down design, lean product development, and GOMS. Further, we found that user-centered design and a usability approach were the most frequently used design philosophies across reviewed products, and are applicable to both design and evaluation. We recommend that developers of consumer health IT applications pay particular attention to these design methods and philosophies when considering design options.

Further, our analysis of successful consumer products revealed that many applications, such as Gmail, Facebook, Second Life®, and Netflix, have tended to utilize design methods that are characterized by high levels of user involvement as well as high levels of iteration. They have engaged consumers extensively and intimately throughout the design process, but have evolved through multiple cycles of prototypes. Therefore we recommend that consumer health IT applications should utilize methods characterized by high user involvement and high levels of iteration. Consumer health IT developers must pay close attention to the voice of the consumer by incorporating techniques for user involvement and feedback throughout the design process; iterate and involve users early and often. The analysis and comparison of design methods shows that methods high in user involvement and iteration are approaches such as crowdsourcing, agile development, prototyping, and contextual design.

We also note that among the top three methods, the design team composition exhibits medium breadth in regard to team size and the skill-sets represented. Very large or highly diverse teams may detract from team effectiveness because of difficulties in communication and coordination (Ancona and Caldwell 1992; Edmondson and Nembhard 2009); however, we recommend that product design teams be constructed such that all the required skills are available among team members. The use of human factors experts as part of many of the successful products' design teams is also noted, and we recommend their inclusion in the design of consumer health IT applications. Further, this is consistent with a user-centered design and usability approach.

As described in Chapter 4, many of the successful products in this study tended to be designed based on a belief that may be summarized as "keep it simple." We recommend that designers choose a parsimonious set of features to include in the application. This is consistent with Facebook, Apple, and Google's design methods as well as studies noting feature fatigue (e.g., Rust et al. 2006). Keeping it simple may also help the design team be more focused in their design activities.

It is important for designers of consumer health IT applications to pay careful attention to user characteristics as this will be an important driver of product usefulness and usability, and subsequently, its adoption. Researchers have identified a number of design principles that are specific to the context of use for consumer health IT applications. Saranto and Brennan (2009) propose several principles for designing consumer health IT applications that should be considered by developers. They recommend that product design should encompass disease

prevention, health promotion, and illness care across the life span; support primary (individual, family, clinicians) and secondary users (payers, public health, quality management, researchers, social services); be accessible by users of different ages with varying levels of health and computer literacy, cognitive and physical ability, and different cultural backgrounds. In addition, by designing consumer health IT applications in a manner that addresses the sensory, physical, and cognitive limitations of patients and their caregivers, risks to quality and safety may be avoided (Henriksen et al.2009).

Further, consumer health IT application design should support the ability to visualize and incorporate data and information (user configurability) according to user characteristics (e.g., age, physical ability, cognitive ability, literacy level) and preferences (e.g., push vs. pull) in a way that is aligned with natural ways of thinking. Although the health care context of use may entail the need to aggregate a range of information sources and data types (e.g. coded, unstructured text, sensor), thereby complicating the design, nonetheless designers need to take these requirements into consideration.

***Additional Recommendations for Designing Hybrid Consumer Health IT Applications.*** In addition to the general design method recommendations across all types of consumer health IT applications, consumer health IT applications that that include the digital application (i.e., software) integrated with a physical device—making up a single hybrid product—should make use of a variety of design methods, much like what companies such as Apple do for developing the iPhone® and TiVo for developing its digital video recording tool. Of special note here is the use of prototypes and consumer feedback based on their use of the prototype that are generally recommended methods in the product design literature. Further, multiple methods may support the need to balance structure in the design process with speed and flexibility.

***Summary of Recommendations:***

For designers of all consumer health IT applications—

- Use methods that include high levels of user involvement and iteration. Iterate and involve users early and often.
- Utilize one or more of the following design methods: prototyping; agile development; heuristic evaluation; top-down design; lean product development; and Goals, Operations, Methods, and Selection Rules (GOMS).
- Ensure the design team has medium breadth in regard to team size and the skill-sets represented.
- Engage human factors experts in the design team.
- "Keep it simple" – Choose a parsimonious set of features to include in the application.
- Pay careful attention to user characteristics.

Additional considerations for designers of hybrid consumer health IT applications—

- Use multiple design methods.
- Use prototypes and consumer feedback based on their use of the prototype.

**Recommendations in Context.** Comparing the successful consumer products to relatively successful consumer health IT applications, we find evidence for the incorporation of some of these recommendations in a handful of the current relatively popular consumer health IT applications' product design. This is especially true in regard to the use of high iteration and user involvement, and designing with simplicity, respectively. For example, GoogleHealth® relaunched in September 2010 with a specific focus on streamlining and personalizing its feature set (Dmitry 2011) and allowing for compatibility with different user characteristics and simplicity. The WebMD® consumer application for smartphones is winning praise for its straightforward and clean interface (Estep 2010). Yahoo!® Health, ranked as one of the most trafficked health information Web sites in April 2011[5], transitioned into an evolutionary rather revolutionary mode, and has supported releasing small creations into production quickly for others to experience and test (ZURBlog 2011). While some of these products may be available to consumers free of cost or be associated with a strong brand name, partially explaining their high adoption, we note that the design of the product is arguably a critical factor in its market success as well.

**Limitations.** We acknowledge the limitations of this research that fall into two broad categories: the product environment and the analytic approach. First, there are numerous factors that influence the success of a consumer product of which the design method is only one. For example, economic factors such as a recession and subsequent availability of consumer discretionary income can influence the adoption and use of goods that are not considered necessities. In addition, the financial resources available to an organization can influence the extent to which it may choose to spend money to promote its product through advertising or price subsidies making that product more appealing than another similar product that may not be subsidized or promoted in the same manner. A classic example is in the VCR industry and the Beta versus VHS video cassette war in which the arguably superior product (Betamax) lost to VHS due to factors including strategic production and distribution alliances (Cusumano et al. 1992).

Second, we focused our research efforts on identifying design methods using an engineering approach to product development beginning with the preproduction design stage. This approach tends to highlight the mechanistic and managerial components of the design process while less attention is paid to the potential aesthetics of the output of the design process (i.e., the product). The advantages to such an approach include recommendations that relate to the design approach used to develop a class of products and not recommendations specific to a particular product. In addition, the design methods included in this report begin with an idea for a product that is then carried forward through various stages of design. The source of inspiration for product ideas was not explicitly included in our analysis.

[5] April 2011 "15 Most Popular Health Sites" on *eBizMBA* Rank (eBizMBA.com. 2011).

Finally, we relied on a variety of sources to conduct this research including the trade press and peer-reviewed literature. Particularly in the case of attempting to identify the design methods used by companies in the development of several recent successful consumer products, the limited information found tended to be predominantly trade press articles. While the trade press is perceived to be less rigorous and reliable than peer-reviewed scholarly journals, it is significantly more current, which is important in understanding how companies are designing recent consumer product successes. To offset this concern, in many cases where trade press citations are used, we include more than one reference to increase our confidence in the claim presented.

# Future Research and Development Recommendations

This section presents recommendations for future research and development related to the design of consumer health IT applications. Our review and environmental scan focused on design methods, and to a lesser extent design philosophies, used in other industries for successful products was motivated by the fact that there is limited systematic knowledge on design approaches for consumer health IT applications. We identify opportunities where the research community can contribute knowledge and help fill gaps in understanding, and areas where the health IT vendor community can assist in accelerating the development of value-adding consumer health IT tools.

## Recommendations for Research

To gain a better understanding on the effectiveness of design methods in consumer health IT application adoption and use, additional research is needed in the following areas:

- Systematic comparisons of alternative levels of user involvement and iteration for different types of consumer health IT applications. For example, experiments can be designed where the level of user involvement for the development of a health information Web site is manipulated and the resultant product evaluated in terms of usability or usefulness.

- The use of qualitative methods to document and isolate successful and unsuccessful design processes currently in use for consumer health IT applications. Researchers can partner with leading vendors of consumer health IT applications to study how these vendors initially develop and subsequently evolve their products.

- Case studies retrospectively documenting design processes and longitudinal studies documenting the evolution of market leaders of the four categories of consumer health IT applications discussed in this report.

- Contingencies that may affect the efficacy of different design methods for different user populations. For example, particular techniques for user involvement may be challenging due to specific user limitations (e.g., reduced vision), additional guidance may be needed on how to ensure adequate involvement of all possible user groups in the design process.

- Investigate user response to products that are modular in nature. Such products would offer increased functionality on a tiered basis so users can select and activate only those specific features that are congruent with their needs.

## Recommendation for the Vendor Community

- Vendors could benefit from sharing information regarding design best practices across the developer community. Industry forums for the dissemination of knowledge related to the design of consumer health IT applications could be a very useful activity.

# Conclusion

The nation's health care system is in a period of transformation, with increasing attention being focused on the potential of digital technologies and tools for enhancing health care quality and reducing the costs of health care delivery. A core aspect of this transformation is the delivery of patient-centered care through improved capabilities to manage their health and health information, coordinate with their health care providers, and assume greater control over health-related matters. This report was motivated by a need to improve the design of consumer health IT applications, which are a key foundation for a more patient-centered health care system. It focused on one of the specific inhibitors of consumer adoption and use: the design of the consumer health IT applications. We reviewed and consolidated evidence on design methods used for the development of successful consumer products in other industries. The insights gained from this analysis were used to develop recommendations for designers of consumer health IT applications and for researchers. While the slow diffusion of consumer health IT applications can be attributed to multiple causes, superior design of consumer health IT applications may promote broader acceptance of these tools and move us closer to the desired goal of safer and more cost-efficient health care delivery.

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# Appendix A: Technical Expert Panel Members

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# Appendix B: Search Terms and Databases

I. Design Method Search Terms and Databases

**Table 1: Search terms used in design methods search**

| No. | Search Terms |
|---|---|
| 1. | Consumer digital product design |
| 2. | Consumer products |
| 3. | Product development |
| 4. | Product testing |
| 5. | Product usability |
| 6. | Software development methodologies |
| 7. | Understanding user requirements |
| 8. | User acceptance testing |
| 9. | User-centered design |

**Table 2: Databases used in design methods search**

| No. | Name of Database |
|---|---|
| 1. | ACM Portal |
| 2. | EBSCO |
| 3. | Google |
| 4. | Google Scholar |
| 5. | IEEE Explore |
| 6. | Lexis-Nexis |

## II. Consumer Product Search Terms and Databases

**Table 3: Search terms used in consumer products search**

| No. | Search Terms |
|---|---|
| 1. | Communication technologies |
| 2. | Consumer design award |
| 3. | eCommerce |
| 4. | Health monitoring |
| 5. | Information search |
| 6. | Information seeking |
| 7. | Information storage |
| 8. | Market leader |
| 9. | Online education software |
| 10. | Online entertainment |
| 11. | Online shopping |
| 12. | Personal finance |
| 13. | Smart phone |
| 14. | Tools and artifacts |
| 15. | User profile |

**Table 4: Databases used in consumer products search**

| No. | Name of Database |
|---|---|
| 1. | CNET |
| 2. | Consumer Reports |
| 3. | Consumer Review |
| 4. | Forbes.com Best of the Web |
| 5. | Google |
| 6. | PC World |
| 7. | Webby Awards |

# Appendix C: Approaches, Theories, and Philosophies Used to Guide Consumer Product Design

| Design Philosophy | Description | Relevant Stage in Development Cycle | Application Contingencies (Industry, Products) | Strengths and Weaknesses | References |
|---|---|---|---|---|---|
| Activity Theory | Activity Theory contends that it is important to understand the consciousness of the user; Without that understanding, it is impossible to reach an optimized design. | All Stages | Useful in all fields but especially in human computer interaction when there is a high level of data transfer or complexity. | Strengths: Leads to a better design that recognizes the more nuanced relationship between a computer and a person.<br><br>Weaknesses: No set plan to follow. Rules are more difficult to interpret. | Nardi 1996, Kuutti 1996 |
| Anthropomorphic Approach | Consists of designing human computer interfaces to show human empathy to the user. Encourages users through pleasant and unpleasant sounds and graphics. | Preproduction design and Design during production | Used for interface design because interfaces can be designed to mimic human emotion. | Strengths: Allows designers to communicate to end users intrinsically. Also allows users to better understand their options.<br><br>Weaknesses: It can be difficult to understand the user's subtle emotional cues and respond appropriately. | Eberts 1994 |

| Design Philosophy | Description | Relevant Stage in Development Cycle | Application Contingencies (Industry, Products) | Strengths and Weaknesses | References |
|---|---|---|---|---|---|
| Cognitive Approach | The brain understands new data best when it is presented in small batches. This method focuses on how the brain interprets information and how to best deliver that information. | Preproduction design, Design during production, and Redesign | Used in interface design. | Strengths: As an adaptation of user-centered design, it allows the designer to meet the cognitive needs of the end user.<br><br>Weaknesses: This is a time-consuming method that requires specialized training. | Eberts 1994 |
| Incremental Product Design | Small revisions to an existing product or idea; used to refine a new innovative idea or can stand alone as a moderate upgrade to an existing product. | Redesign | Most often used as a standalone design practice by companies that attempt to make an improvement to an existing design; used in all competitive industries. | Strengths: Fast to market and usually based on successful consumer accepted products; through several small iterations, any suboptimal product can become much more desirable to the public.<br><br>Weaknesses: Tends not to lead to innovative ideas initially | Cooper 1994, Kleinschmidt 1991. Levitt 1966, Olsen 2006 |

| Design Philosophy | Description | Relevant Stage in Development Cycle | Application Contingencies (Industry, Products) | Strengths and Weaknesses | References |
|---|---|---|---|---|---|
| Multiplayer agent methods | Similar to crowdsourcing; difference is that multiplayer agent methods are often used to test a product whereas crowdsourcing is used to generate ideas. | Redesign | Most commonly used in human computer interface design because it is easily testable online. | <u>Strengths:</u> Provides access to a "diverse, heterogeneous and distributed on-line information sources, but also as a framework for building large, complex and robust distributed information processing systems which exploit the efficiencies of organized behavior."<br><br><u>Weaknesses:</u> Difficult to focus people involved in multiplayer agent games; could cause negative public reaction to a new product. | Shen 2001, Wu 2010 |

| Design Philosophy | Description | Relevant Stage in Development Cycle | Application Contingencies (Industry, Products) | Strengths and Weaknesses | References |
|---|---|---|---|---|---|
| Usability Approach | Related to user-centered design, this philosophy considers how people will use the product and how easy it is to use from the beginning of the design stage. | All Stages | All industries, but especially used for human computer interaction processes and Web sites; rules are designed to address how simply information can be sorted through so that the desired piece of information is transferred. | Strengths: Helps the design team quantify what design decisions will produce a usable design; simplifies the job of the designer; human computer interaction design team does not have to understand the human brain structure to determine how best to design the site; it just has to follow the rules.<br><br>Weaknesses: Does not take into consideration human error or interest. | Thomas 2002 |
| User-Centered Design | A design process that focuses on the customer's needs, wants and capabilities. Designers must foresee how the product will be used correctly and what potential user mistakes exist. It does not try to get users to change their behaviors. It tries to meet their existing needs. | All Stages | Almost all industries and products use user centered design; most often for technical products where users have to learn how to use a complicated interface quickly and intuitively. | Strengths: A product has a greater chance of meeting the customers' existing needs based on input from focus groups, surveys, and customer interaction.<br><br>Weaknesses: Product design cycle is more costly and takes longer; product might be designed for a specific test market that is not representative of the larger population. | Abras 2004, Norman 1986 |

| Design Philosophy | Description | Relevant Stage in Development Cycle | Application Contingencies (Industry, Products) | Strengths and Weaknesses | References |
|---|---|---|---|---|---|
| Design Driven Innovation | A strategy aimed at radically changing the emotional and symbolic content of products through an understanding of changes in society, culture, and technology. Relies on the proposal of new product meanings from interpreters (e.g., designers, suppliers, artists, the media) and not an examination of user needs. | Preproduction design and Design during production | Originated with Italian manufacturing companies but approach has been applied by companies such as Nintendo to make video gaming accessible to women and families and Swatch to shift consumers' idea of a watch as a timepiece to that of a fashion accessory. | Strengths: Yields increased understanding of the market and potential to shape customer demand using a multifaceted network of a firm outsiders.<br><br>Weaknesses: Risky approach as failure rate of new products can be high; hiring of designers to interpret changes in environment into products is challenging. | Verganti 2009 |

# Appendix D: Consumer Product Categories by Degree of User Involvement and Iteration

This graph details the relative prevalence of product design method by degree of user involvement and iteration across the seven categories of digital consumer goods analyzed. The graph shows all seven product categories utilize design methods characterized by high user involvement iteration and high iteration. The prevalence of use of design methods characterized by a medium to high degree of iteration is pronounced. No reviewed products used methods characterized by low iteration.