Designing a Web-based Behavior Motivation Tool for Healthcare Compliance

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ABSTRACT

As one of the causes of increasing population with chronic diseases, low compliance with healthy lifestyle has been a major challenge in healthcare. Not seeing immediate positive outcomes, many people became frustrated and stopped adhering to health plans that offer long-term benefits. Studies have suggested that peer supports be effective to improve compliance, and social cognitive theories have indicated that personal realization and confidence enhanced through entertaining gaming elements could encourage behavior change. In this study, we propose a Web-based behavior motivation tool to help improve patients’ health compliance based on previous work and theories. Key components in our service design are illustrated through a case study, including a social gaming and learning portal, an engineering approach to support different application scenarios, and information interventions based on predefined rules to achieve effective compliance.

Keywords: social networking, service design, healthcare compliance

1 INTRODUCTION

Chronic diseases are projected to become a main cause of death and account for more than half of global disease burden in the near future (WHO 2005). The need for healthcare system to adapt to this change through technologies and innovations is apparent. Cost-effective approaches to promoting health, preventing major risk factors for chronic diseases, and changing lifestyles, are top priorities for relatively
healthy population. Unfortunately, there has not been significant progress in behavior modification tools towards healthy lifestyles, in spite of the large amount of information made public about how to reduce risks of developing common chronic diseases (Yu et al. 2012).

Studies (Conway et al. 1996, Greco et al. 2001) speculated that through small group interactive sessions, peer support, and realization of others having similar conditions may help people improve compliance. However, peers may sometimes have negative influences (Thomas, Peterson, & Goldstein 1997). Therefore it is not enough to depend solely on peer supports for motivation. In social cognitive theory (Bandura 1977, 1986), behavior change is a function of enhanced skills and confidence (self-efficacy) in forming the new behavior. Self-control procedures, such as goal setting, and gaming elements may enhance behavior change through aspects of intrinsic motivation (Baranowski et al. 2008). Research indicates that the reason people spend time on online games and social networking sites may be related to psychological needs of self-esteem (Colwell, Grady, & Rhaiti 1995) and collective self-esteem (Barker 2009). A social networking portal with gaming elements is proposed in this study as an information-based intervention to improve compliance with exercise or diet prescription for chronic disease prevention.

Psychological game theory (Geanakoplos, Pearce, & Stacchetti 1989; Battigalli 2009) was introduced as a game validation tool for the proposed social gaming portal. In mathematics, game theory models games and strategies, in which an individual's success is depending on not only his own choices but also choices of others (Myerson 1991). Behavioral game theory (Camerer 2003) extended the base of analytical game theory by adding elements of emotion, mistakes, limited foresight, doubts, and learning. Instead of emphasizing on the limitations of what human can reason in a behavioral game, this study concerned about what psychological payoff people may gain from a social gaming portal. Psychological game theory revealed that belief-dependent motivations, which generate payoff that tends to be psychological, may be important to strategic players. From a different angle, portal designers also need to avoid players "gaming the system." Mechanism design, a field sometimes called reverse game theory, fills this gap by analyzing whether the proposed social gaming mechanism is "strategy-proof," so that no player can cheat and deviate from the predicted behavior. Moreover, expressive service blueprinting, a constructive service design approach for viewing service offerings from the customer's perspective with emotive states (Spraragen & Chan 2009), is used to present and validate the new service flow. This is important because the new service flow based on the proposed social gaming portal involves manual operations that are beyond pure information technology (IT).

The structure of the study is as follows. The specific healthcare compliance problem is detailed in section 2. Section 3 presents the design of a Web-based tool for healthcare compliance. Section 4 then extends the IT-based tool into a new service and validates it. In section 5, a service design and engineering approach, general enough to solve similar behavior motivation problem, is proposed. Section 6 presents limitations of the study. Finally, section 7 concludes the study.
2 HEALTHCARE COMPLIANCE PROBLEM ON WORKSITE

The focus of this healthcare compliance research was on worksite health promotion programs, which have emerged as an important corporate strategy to improve employee health and productivity (Goetzel 1998, 2000; Ozminkowski 2002). The following five pain points were indentified based on interviews with corporate employees and officers from an external health screening service provider:

i Exercise and diet prescriptions given to at-risk employees were often neglected.

ii Most employees were not motivated to take the given prescriptions due to slow or little wellness progress.

iii Although monetary incentives were provided to encourage employees to take fitness/diet courses, it was difficult to confirm cost effectiveness due to lack of actual exercise/diet records.

iv Corporate health clubs failed to effectively promote fitness programs through influence by exercise champions

v There were no effective ways to monitor diet compliance.

Hence, we proposed to design a facebook-like social networking/gaming portal inside corporate firewall to improve compliance with exercise/diet prescriptions by leveraging peer influence of exercise champions. Literature survey (Steinberg & Silverberg 1986; Berndt 1992; Conway et al. 1996; Greco et al. 2001; Baranowski et al. 2008) showed that general motivation tools that engage peer supports, gaming elements, social gaming, and mission-based learning (Shih & Chen 2002) could be fundamental constructs for such portal design. Figure 1 illustrates an ideal process of leveraging dynamic formation of peer support and social gaming to gradually motivate employees to change their behavior. The portal keeps exercise/diet records, and provides responsive feedback.

Figure 1 Motivating the desired behavior through mission-based learning

3 A WEB-BASED TOOL FOR BEHAVIOR MOTIVATION

A Web-based social gaming portal for behavior motivation, comprising three categories of modules (Figure 2), was delicately designed based on the above assumptions and theories. The modules are briefly explained in the following.
The first category of modules is social gaming modules, allowing general social activities, like social networking, chatting, and gaming, to be conducted online. The design challenges are: abstraction and reusability (Wegner 1983; Krueger 1992). A generic architecture design could allow us to reuse the modules in domains other than healthcare (see Section 5). The well-known Model/View/Controller (MVC) (Krasner & Pope 1988; Leff & Rayfield 2001) design pattern was used for our system architecture. The resulted modules are named as a generic Mission-Oriented Social Gaming and Learning (MOSGAL) platform.

Service composition modules are in the second category. The services to be composed are Web Services (Alonso 2004). The proposed health management service flow (see Section 4) in our case consists of six steps: risk stratification, progression model design, intervention portfolio design, personalization, compliance, and intervention adaptation. Because the MOSGAL platform supports the last three steps in the service flow, any party that performs the first three steps could use the service composition module to integrate MOSGAL, or "behavior motivation as a service," into their existing services to form a new service. Health screening centers, hospitals, and fitness centers are targeted partners for service compositions.

Finally, modules of social media analytics (Melville, Sindhwani, and Lawrence 2009), an emerging discipline for automated analysis of social media, provide ways to analyze the data on the portal for acquiring useful information. For example, a "heat map" of mission combination and frequency is used to calculate the "distances" (Deza & Deza 2009) between two users of the portal. The distances are then used to create peer supporting groups and social gaming groups as shown in Figure 1. The intelligent algorithms for creating groups are detailed in another paper.

4 DESIGNING A NEW HEALTH MANAGEMENT SERVICE

As noted in the last section, the thorough health management workflow in our case contains six steps, from risk stratification to intervention adaptation. Because
the proposed Web-based portal covers only the last three steps of the service flow, we co-designed a new service with a Taiwanese health screening service provider (MJ Life) to integrate the portal with their services, using expressive service blueprint, and validated the gaming structure with our game theory expert.

4.1 New Service Design via Expressive Service Blueprint

Because the targeted end users are employees on worksite, the customer journey starts from employees getting health screening package from HR department. We used an expressive service blueprint (ESB) (Spraragen & Chan 2009) to map out the customer journey for employee health screening (Figure 3a). Different from standard process management tools, using this ESB we were able to detail interactions and emotive responses between the employees and MJ service team. This was valuable for us to mark the alignment between the service goals and the employee’s expectations. Based on the health screening data and chronic-disease risk assessments, MJ care managers designed progression models, confirmed intervention portfolios, and offered personalized exercise/diet prescriptions to employees, which were conveyed via the behavior motivation portal (Figure 3b). Employees were rewarded with "experience points" after they completed missions (Figure 4), and the portal supported both Web-based and mobile applications for peer grouping and social gaming (Figure 5).

Figure 3a New Health Management Service Blueprint Part I

Additional rewards for high compliance were announced by the portal after three months. Employees must visit care managers again for follow-up tests before claiming the rewards. Care managers will adapt employees’ prescriptions based on compliance reports and new health screening results. The expressive service blueprint proved to be useful for brainstorming new ideas of service or experience design when our IT engineers and partner’s service design team work together.
Figure 3b  New Health Management Service Blueprint Part II

Figure 4  Personalized exercise/diet prescriptions for an employee

Figure 5  Social Gaming with Your Colleagues (Mobile Version)
4.2 Game Theoretic Validations

As discussed in Section 1, it is assumed that the behavior motivation portal creates repeated psychological games with invariant strategy space. Each user (employee) is given a chance to join the game when participating in the corporate health screening program. After he/she joins the behavior motivation game, he/she is presented with several options to act upon, as show in Figure 3.

![Figure 3 Payoff of the Repeated Games of Behavior Motivation](image)

The utility function is defined as follows: $u_i : E \times O \times L \times M_i \rightarrow \mathbb{R}$, where $E$ is the set of terminal histories of all users' experience points, $O$ is the set of terminal histories of all users' rankings, and $L$ is the set of terminal histories of all users' number of "likes." $M_i$ is a set of $i$'s initial beliefs about other's strategies and initial beliefs. Assuming all participants of the game have beliefs that each experience point, each high ranking, and each "like" can generate positive utility, then this is common knowledge. In Figure 3, $x$ is the accumulated experience point, $y$ is the accumulated high ranking, and $z$ is the accumulated number of "likes." Then $(x,y,z)$ is the representation of a user's psychological payoff. While "+" denotes a probability of increase, "-" stands for a probability of decrease. The gaming rules and structure are:

1. When a participant reports compliance to the portal, he gets positive experience points $P$, and one quota of receiving a "like" from each friend; otherwise he gets zero points, and no quota for receiving a "like";
2. When a participant answers today's quizzes, and the answer is correct, he gets positive experience points $Q$; if the answer is incorrect, he still gets positive experience points $Q/2$;
3. When a participant answers past quizzes correctly, he gets $Q/3$ experience points; if incorrect, he still gets $(Q/3)-1$ experience points;
4. When a participant sends a "like" for his peer, he gets a chance of receiving a "like" back. However, the participant must have the quota of receiving "likes" before he can receive a "like."

These rules demonstrate that desired user behaviors can be motivated through proper rewards on actions. Cheating behaviors, on the other hand, are solved by a reputation mechanism using a creditability coefficient $r$ ($0 \leq r \leq 1$), which is to be
multiplied by gained experience points to produce adjusted experience points. If a significant number of reports on a given user’s cheating behaviors are received by the portal administrator, the creditability coefficient of that user will be decreased permanently to reflect his or her true experience points.

5 INNOVATING MOTIVATION-EMBEDDED SERVICES

The emergence of Service Science, Management, Engineering, and Design discipline (Spohrer & Kwan 2008) indicates the need of a systematic approach for innovating service systems. Service innovations can begin with technology, involving social-organizational novelty, and then contributing to business innovations (left diagram in Figure 4, adapted from Spohrer 2006). Within this particular process of service innovation, one needs to address issues on engineering, design, and management. During the development of this Web-based behavior motivation tool, a simple and intuitive service innovation matrix was devised for guiding these innovations. The matrix comprised three phases of feasibility studies and three types of issues to be addressed (right table in Figure 4). Problem solving techniques relevant to each feasibility study in each type were identified. The proposed matrix is useful for service innovations with embedded mechanisms for user behavior motivation. In addition to healthcare applications, we plan to apply it to corporate security or policy programs to improve employee compliance.

![Figure 4 Service Innovation Matrix for Behavior-Motivation-Embedded Services](image)

6 LIMITATIONS OF THE STUDY

Although service feasibility of the proposed mechanism was proved by in-lab service trials with a local health screening service provider, analysis of the service trial results will be elaborated in consequent papers. For a case study of human-side service engineering, it is demonstrated that a complex service innovation involving technology and business novelty could be accomplished by fusing problem-solving techniques from different domains. However, to validate clinical benefits we still face numerous challenges. Compelling trial studies, such as randomized controlled trials, could involve thousands of subjects and take years to complete (Moher 2010),
which will be our long-term goal but beyond the scope of this study.

7 CONCLUSIONS AND FUTURE WORK

Social gaming concepts are not new to healthcare compliance, but the proposed behavior motivation portal has four unique features: (1) Seamless integration of mission-oriented learning with dynamically formed peer supporting and social gaming groups. The mission-based learning design is highly customizable and can be aligned with corporate health promotion programs. (2) Capability to expand the service scope via service compositions with external parties, including health screening providers and fitness centers. (3) The introduction of social media analytics to learn user behaviors and to improve the effectiveness of the portal. Analytic results can be combined with the research of artificial intelligence to conduct automated coaching. (4) Exploitation on the advantages of corporate working environment for better compliance, in particular, mitigated security and privacy risks behind a corporate firewall, homogeneous working environment, and high computer literacy. Besides the developed health management service, a service innovation matrix is proposed to guide motivation-embedded service innovations. Applying the matrix in domains other than healthcare is our immediate future work.

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