Journal of Biomedical Informatics 71 (2017) 198–206

Contents lists available at ScienceDirect

Journal of Biomedical Informatics

journal homepage: www.elsevier.com/locate/yjbin

# Creating a sustainable collaborative consumer health application for chronic disease self-management

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ARTICLE INFO

*Article history:*
Received 11 November 2016
Revised 15 May 2017
Accepted 4 June 2017
Available online 6 June 2017

*Keywords:*
Consumer health informatics
Virtual environments
Chronic disease
Self-management
Type 2 diabetes

ABSTRACT

As the prevalence of chronic diseases increase, there is a need for consumer-centric health informatics applications that assist individuals with disease self-management skills. However, due to the cost of development of these applications, there is also a need to build a disease agnostic architecture so that they could be reused for any chronic disease. This paper describes the architecture of a collaborative virtual environment (VE) platform, LIVE©, that was developed to teach self-management skills and provide social support to those individuals with type 2 diabetes. However, a backend database allows for the application to be easily reused for any chronic disease. We tested its usability in the context of a larger randomized controlled trial of its efficacy. The usability was scored as 'good' by half of the participants in the evaluation. Common errors in the testing and solutions to address initial usability issues are discussed. Overall, LIVE© represents a usable and generalizable platform that will be adapted to other chronic diseases and health needs in future research and applications.



## 1. Introduction

In the past 10 years, advancements in technology, increasing broadband and internet access, and increased ownership of home computers and mobile devices have encouraged designers and researchers to build consumer health applications centered on health promotion and disease prevention and management. These applications provide not only a means to potentially improve health communication and education, but have potential to assist consumers with making changes in health behaviors. With the increased need for services following implementation of the Affordable Care Act, and the ongoing chronic disease epidemic, the demand for new media to help consumers self-manage their disease(s) also increases. In the U.S., about one-half of all adults have a chronic disease [1] and about one-quarter have two or more chronic diseases [2]. Diabetes affects 29.1 million Americans, the majority of whom have type 2 diabetes (T2D) [3]. Individuals with T2D provide 99% of their own care [4] and thus self-management (physical activity, diet, glucose testing, etc.) is critical to maintaining wellness. To control costs, eliminate barriers to healthcare and assist individuals to self-manage their disease, individuals need not only education on self-management skills, but social support [5], and frequent patient-provider interaction [6,7]. Implementation of the multicomponent Chronic Care Model [8] has shown that patients with chronic disease who have productive and planned interactions with a health care team and who have self-management support augmented by resources in the community have improvements in health outcomes [9].

Resources in the community to augment self-management skills of health consumers include eHealth tools. eHealth tools are health information resources such as mobile apps and internet – based resources which may provide education, online forums, and peer and provider support. Consumers with chronic disease who are actively engaged in their health care through the use of eHealth tools have improved knowledge [10–13], self-management behaviors [11,12,14,15], social support [10,13,15] and self-efficacy [10,11,15] with regard to managing their disease.

The participatory internet provides new ways to cultivate engagement between consumers, and consumers and providers. Many applications focus on changing health behaviors, yet most are disease specific or track specific health parameters. Due to the pervasive problem of chronic disease, including multiple comorbid chronic diseases, the demand for self-management of these diseases, and the need for cost containment, we need to build

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http://dx.doi.org/10.1016/j.jbi.2017.06.004
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consumer health applications that are applicable or transferrable to any chronic disease. An application that utilizes a database as its core structure can meet this goal. Building such an application is cost effective since the main application remains the same and only the contextual information changes.

We developed a theoretically grounded, technologically-based, bio-behavioral virtual environment (VE) to facilitate self-management of diabetes [16]. We are evaluating the efficacy of this VE on diet, physical activity, and metabolic outcomes in our current multi-site randomized controlled trial (NHLBI 1R01-HL118189-01) [17]. This enhanced version, called LIVE© (Learning in a Virtual Environment), is based on our preliminary work in Second Life (SLIDES) [18]. Similar to SLIDES, LIVE© was built as a virtual community for diabetes self-management training and support and was constructed as a virtual 3D community with disease specific information embedded in objects located in virtual stores within the site [17]. Participants with T2D enter this environment through a website 24/7 and they self-represent as avatars within the site. While in the site, they can access information located within objects in any of the virtual stores, attend diabetes classes moderated by diabetes educators in real-time, participate in the text only forum, watch previously recorded classes, interact synchronously with other participants or diabetes educators via voice, co-create content on the site, or play interactive games. The goal of this paper is to provide information on how we built this virtual software platform using a 3-tiered Model-View-Controller (MVC) architecture which we describe in detail below. Although the content developed in this VE study focuses on T2D we built the back-end of the VE to be disease agnostic where the content could be easily changed in the database and thus could be straightforwardly modified for any chronic disease.

## 2. Methods and materials

The LIVE© environment was collaboratively built by experienced game developers, study investigators, diabetes clinicians and educators. This VE was built with Epic Games Unreal ® Engine 3 (Cary, NC), which is the third iteration of the Unreal Engine. Level designers created levels using the Unreal Editor, a suite of tools for working with content in the Unreal Engine and the game logic was created using Unreal Script, a scripting language developed specifically for the Unreal Engine and C++.

### 2.1. Phases of the build

#### 2.1.1. Agile Scrum

LIVE© was created using a Scrum development process [19]. This process involves rapid iteration with constant communication between developers and the investigator stakeholders. The first part of the process was to determine the requirements of the system with the goal of creating a Game Design Document, which the investigators and the developers could reference during development.

The requirements in the Game Design Document were broken into user experiences known as ‘stories’. All of these ‘stories’ were added to a list called the ‘backlog’. Throughout development, additional stories were added as new functionality requirements arose through iteration and needs of the investigators. The development cycle involved 2–3 week long development iterations known as sprints [20]. Each sprint consisted of pulling a set of stories from the backlog to complete each story. For example, one sprint was to create an environment with non-player characters and interactive objects. The team discussed the progress of each sprint each day and resolved any problems associated with a particular sprint. At the end of each sprint, completed stories were removed from the project while incomplete stories were moved to the backlog. Often at the end of the sprint, deliverables were shown to the investigators to obtain feedback about a new feature or modifications of an existing feature.

#### 2.1.2. Build phases

This project followed the traditional game development phases of alpha, beta, and gold master. The development team worked closely with the investigators, who iteratively reviewed and tested the different phases of the game development and suggested changes to the functionality as needed. The alpha deliverable had functional core systems with placeholder assets and interfaces (characters, props, etc.). Once the core game systems were established, the beta phase refined and improved game systems as well as implemented high quality game assets. The gold master phase addressed final bugs, system refinements, and artistic enhancements to create the final version 1.0 of the game. As this game is a massive multi-player online (MMO) game, continual refinements and enhancements were made to the application with incremental updates and two additional functionality enhancement cycles. Examples of this project’s items in each phase are shown in Table 1. Overall, the cost of creating this environment including the data structures was $415,000. There were additional costs for end-user support over a period of 5 years, which equaled $85,000. However, considering that the application could be reused for other diseases, the costs for reuse would be significantly less.

### 2.2. User-centered design

As with Scrum, user-centered design is an iterative process. The main goal in user-centered design, especially applications designed for health care consumers with various levels of computer literacy, is to create an application that takes into consideration not only the characteristics of the users, but the goals and tasks of the users [21]. Throughout the design lifecycle, we took into consideration any problematic usability issues in our prior Second Life VE [18]. For example, in our previous version (SLIDES), we embedded information into 200 different grocery store items, which required the participants to find each item located in a virtual store, but also click and close each individual item. In our new version (LIVE©), we simplified this process, so that the number of steps were reduced to two and only required pointing at any virtual item in the grocery store, whereupon a tabbed window appeared that allowed participants to scroll through all of the available grocery store items and accompanying information. We employed these easy to use customizations throughout the VE.

#### 2.2.1. Usability study

We validated our interface design decisions through a small-scale usability study with a convenience sample of our enrolled initial participants (n = 10). Small-scale usability studies are a way to discover hidden usability issues [21]; 5–12 users will identify 80–90% of the major problems with a system [22–24]. Therefore we recruited 10 representative participants. Upon enrollment into the study, participants were asked if they would like to take part in a usability study that would take approximately one hour to complete. With IRB approval, in a controlled lab setting, participants were first informed about the purpose of this study and were then given training on the talk-aloud technique [25] using a simple math problem and scrambled letter technique. Participants were then given a series of 42 frequently used tasks to complete within the VE while talking aloud and were assessed for successful completion of each task. The investigator conducting the usability testing observed the participants logging into the VE and then observed them as they completed a list of tasks such as going to each place in the site, finding items in each place and using the var-