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A game plan: Gamification design principles in mHealth applications for chronic disease management

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Abstract
Effective chronic disease management is essential to improve positive health outcomes, and incentive strategies are useful in promoting self-care with longevity. Gamification, applied with mHealth (mobile health) applications, has the potential to better facilitate patient self-management. This review article addresses a knowledge gap around the effective use of gamification design principles, or mechanics, in developing mHealth applications. Badges, leaderboards, points and levels, challenges and quests, social engagement loops, and onboarding are mechanics that comprise gamification. These mechanics are defined and explained from a design and development perspective. Health and fitness applications with gamification mechanics include: bant which uses points, levels, and social engagement, mySugr which uses challenges and quests, RunKeeper which uses leaderboards as well as social engagement loops and onboarding, Fitocracy which uses badges, and Mango Health, which uses points and levels. Specific design considerations are explored, an example of the efficacy of a gamified mHealth implementation in facilitating improved self-management is provided, limitations to this work are discussed, a link between the principles of gaming and gamification in health and wellness technologies is provided, and suggestions for future work are made. We conclude that gamification could be leveraged in developing applications with the potential to better facilitate self-management in persons with chronic conditions.

Keywords
consumer health, health informatics, innovation, mHealth, patient engagement

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Background and significance

Chronic non-communicable diseases (NCDs), including cardiovascular and respiratory diseases, cancer, and diabetes, are a significant cause of morbidity and mortality, worldwide.[1] According to the World Health Organization (WHO)[1] World Health Statistics report, 36 million deaths (63% of the global total) were attributed to chronic NCDs in 2012. Though treatment strategies and management for NCDs are highly variable, depending on the specific NCD, vigilant patient self-care is essential to improved prognostic outcomes, particularly in persons with cardiovascular and respiratory diseases, as well as diabetes.[2,3] Treatment adherence and self-management is often inadequate or inappropriate, resulting in a large annual financial burden to the US health system.

King et al.[4] reported mobile health (mHealth) applications to be an effective conduit for the delivery of health interventions. With the increasing adoption of smart devices and the continued development of mHealth applications, the mHealth market is on the rise.[5,6] According to the Mobile Health Market Report by Research 2 Guidance,[7] a mobile applications market analysis firm, it is projected that by 2018 there will be 3.4 billion smartphone users, of whom 50 percent will have downloaded at least one mHealth application. mHealth applications thus serve an important role in better facilitating self-care. A burgeoning feature of mHealth applications very recently being leveraged to improve self-management behaviors is gamification.

Gamification is defined as the implementation of the most common and enjoyable mechanics of video games, in non-video game contexts.[8,9] Badges, leaderboards, points and levels, challenges and quests, as well as social engagement loops and onboarding are among the most commonly implemented mechanics of gamification.[10] According to Gartner,[11,12] it is projected that by 2015, 50 percent of industries will gamify their innovation processes, though 80 percent of gamified applications are expected to fail to meet business objectives, due to a lack of research around suitable game design, as well as poor rationale or design of gamification mechanics.

While several studies have outlined the concepts of gamification as they apply to health, very little research has focused specifically on the mechanics of gamification, particularly regarding a rationale for their use and how best to apply them to mHealth applications.[8,14] Due to this current limitation, this review article will outline the various gamification mechanics as they have been organized by Zichermann and Cunningham,[10] and as they are featured in several mHealth applications. The candidate applications selected for discussion—bant, mySugr, RunKeeper, Fitocracy, and Mango Health—were selected as they (1) are classified as mHealth applications, including fitness, and (2) feature at least one of the mechanics described by Zichermann and Cunningham.[10]

Gamification mechanics

Gamification features, herein referred to as "mechanics," are integrated into the greater context of the application for purposes of bolstering usability and by appealing to those facets of video games which gamers typically enjoy, and which compel continued play. An understanding of these mechanics and their associated design and development considerations, as contextualized through mHealth application examples, could aid in guiding the development of gamified mHealth applications that could better incentivize patient self-management.

Badges

Badges, achievements, trophies, and other such concepts are used to identify and reward individual achievements.[10] There are primarily two kinds of badges: absolute and relative.[15] Absolute badges

can be attained by meeting nonrelative goals, such as achievement benchmarks, while relative badges are limited achievements rewarded to users relative to their peers.[15] They can be seen as similar to Olympic medals; only a subset of users can receive them for distinct, often difficultly attainable, goals. Upon completing a task and being awarded a badge, users may feel less inclined to adopt or maintain the behavior without further reinforcement from the system, as would be facilitated by the implementation of additional gamification mechanics, as such it is not advised that badges are the only mechanic used.[15]

Zichermann and Cunningham[10] suggest that badges should not be patronizing in their descriptions, such as being over-congratulatory, or by rewarding rote tasks. They should also be meaningful and anticipatory to the recipient as opposed to being awarded randomly, without notice or warrant. In addition, badges should be appropriate to the goals of the application. For example, mHealth users should not be rewarded for poor behavior or failing to meet objectives as they are defined by the application. A dashboard should provide a summary of all badges obtained.

Fitocracy is a robust mHealth fitness tracker application that uses badges and which enables users to visualize their performance, and contextualize their personal progress with that of their peers.[16] Ranging from completing a set number of bench presses or pull-ups, from running, to squats, even to the use of the social features of the application (see social engagement loops and onboarding, below), users can achieve "badges" by completing the task described, and refer back to them through their "achievements" dashboard. Badges are awarded for meeting objectives such as bench pressing a given repetition of weight up through to running or swimming 20 or 100 km in their lifetime. The achievements are colorful and engaging with different images on each achievement, and there are a sufficient number of badges available to incentivize continued use in motivating the user to attempt to earn them all.

Leaderboards

Leaderboards dynamically rank individual user progress and achievements as compared to their peers.[17] Leaderboards can represent to a user their position relative to others, providing them a sense of how well they are using the application as compared to their peers.[17] Users should be able to see their position in the context of others, as facilitated through a numbered ranking system, for example, as well as have an understanding of what constitutes their position on the leaderboard and what actions can be taken to ascend the leaderboard with respect to their peers. A user may toggle between other users in their personal network, or users of the application from around the world to gauge their progress in a larger context. Users may then see how they "rank" as compared to their peers in the context of their local and global networks.[10] Depending on the design and intent of the application, additional columns and filters can be added to provide a number of other, relevant elements, such as the time the application has been used, and for the fulfillment of explicit application goals.

RunKeeper is a global positioning system (GPS)-enabled fitness manager application that enables users to initiate and track a number of different activities, set fitness goals, and take on custom challenges as recommended by the application.[18] The application has a very simple, yet engaging leaderboard that can optionally be synced with the user's social network, either through Facebook or via their personal email contacts list. The leaderboard orders friends by activities completed and it is updated monthly. Leaderboard position is represented by a number and green-to-red spectrum color-code tab, which provides the user visual context as to their level of activity (dark green—most active, dark red—least active). The user with the number one position on the leaderboard gets a ribbon icon next to their name, while users with red tabs are cheekily assessed a sofa icon, suggesting their relative inactivity.

Points and levels

Points and leveling systems are implemented to inform the user of their level of familiarity, and reward continued expertise and knowledge using the system.[10] This is typically achieved through assessing the user additive, predetermined point values and by assigning users metaphorical icons or titles, otherwise known as levels, as they progress through the application. This metaphor for user experience is important to driving social user engagement, as new and potential users are more likely to engage with more experienced users, as evidenced through their point and level values.[19]

It is advised that application user experience be reflected through a progressively nonlinear point and leveling system with ranking or insignia to document progress benchmarks.[10] For example, achieving "level 1" may require minimal effort, such as through adding entries as specified by the application, but each subsequent level should necessarily be increasingly more difficult to attain. To reinforce this non-incremental, progressively more demanding leveling system, it is advised that levels be ranked similar to the ranking system used in the US military, where the first rank, or level, "private" is represented by one chevron, and the second rank, "corporal/specialist" is represented by two stacked chevrons. The specific insignia can take whatever design and title the developer chooses, of course. Ranking insignia should change slightly as the user achieves successive ranks so as to provide the user a developing visual graphic which metaphorically represents their development. Progress bars are also a very common feature of points and levels, because user can see how many points they have attained along a continuum, and how many more points they need to acquire to achieve the next level, thus motivating their continued use, especially when they can see they are on the verge of attaining a new level or benchmark.[10]

Mango Health is a medication and nutritional supplement manager application that enables users to input their medications and set reminders for their drug regimen.[20] The application includes a comprehensive pharmaceutical database that provides users with dosing information and potential contraindications, potentially controlling against unsafe drug interactions. Users earn points for inputting their medications and taking them regularly and on time. As users accrue points, they "level-up" and, the higher their level, the greater chance they have of winning prizes. Level 2 users, for example, can win a US$1 donation to the American Society for the Prevention of Cruelty to Animals (ASPCA), and level 3 users have a chance to win a US$5 gift card for shopping at Target. Prizes increase in value as higher levels are attained. User accrual of points, leading to higher levels, is thus reinforced by tangible rewards in the form of cash value vouchers, as well as the intrinsic reward of effectively using the application to manage their individual drug regimen.

Similarly, bant is a diabetes management application, that is able to capture data from the user's blood glucose meter over Bluetooth automatically.[21] When users take readings on a regular basis they earn "experience" points. They receive bonus points for taking a minimum of five reading a day. They also receive a 2X point multiplier for taking the often-avoided lunchtime reading. Just as with Mango Health, users accrue points and "level-up". These points can then be redeemed for iTunes redemption codes to purchase music and apps.

Challenges and quests

Through continued challenges and quests, users may be motivated to continue using a system or application, especially where these challenges validate their understanding of the goals of the application.[10] Many of the mechanics of gamification would be of little to no meaning to a user in the absence of an underlying narrative, comprising checkpoints or benchmarks, indicating that the user is, indeed, using and progressing through the system as it was meant to be used.[10] Challenges and quests are effective methods to drive other gamification mechanics.[10] For example, they can be

nested within badges, assigned point values for a leveling system, or quantified to sort users on a leaderboard. It is recommended that challenges be variable in option, static, and readily available for the user to attempt as opposed to being imposed as well as educational in that they teach the user how to use the application.

mySugr Companion is a diabetes management application that enables users to manually input blood glucose readings, indicate their mood through a number of creative and descriptive icons, record their dietary habits, provide nutrition facts, and take pictures of their food for ease of recall.[22] In addition to these and other features, mySugr features a novel points system, whereby the user gains points through completing tasks such as taking pictures of their food and inputting their blood glucose and their moods. Completing daily challenges contribute to a dashboard progress bar that, when full, "tames" their mySugr "diabetes monster," a daily avatar that effectively provides feedback to the user regarding whether they have taken adequate steps in managing their diabetes for the day. Challenges are regularly updated to provide the user sufficient options to keep them motivated to use the application.

Social engagement loops and onboarding

By enabling data and information sharing between patients, the integration of social media platforms, such as Facebook and Twitter, have the capacity to motivate continued user compliance.[23,24] Implementing social media interface facilitates social engagement loops in two notable ways. First, users may wish to share personal data and achievements from their application so as to build social capital with other peers using the same application, as well as to garner support from these peers.[25] Furthermore, these loops mediate onboarding, whereby new users are brought into the system via invites from existing users, with new users being further compelled by other implemented gamification mechanics and the inherent benefits they gain by using social media. These new users may, in turn, invite peers from their respective social networks to join and participate, thus perpetuating this social engagement loop.[10]

Zichermann and Cunningham[10] note that the first minute of use of a given application heavily determines whether that user will continue to use the application in the long-term or whether they will delete it altogether. A popular method to incentivize continued use is through the implementation of a tutorial that quickly, yet comprehensively, walks the user through the use of the application. Whether through a static page, or interactive, gamified interface, tutorials strive to ensure the user has an understanding of how to interact with the application comfortably, minimizing frustration and thus the potential for drop out.[26] Ideally, if the tutorial can educate the user about their specific condition, including the significance of the actions they are taking when using the application, this could contribute to a deeper understanding of their disease and course of treatment, which is essential to fostering long-term, sustainable use of the application and thus improved self-management.[27,28]

RunKeeper (see "leaderboards" for description of the application) leverages social engagement loops and onboarding in a number of ways.[18] Upon starting the application for the first time, the user is given the option to sign-up through Facebook or by using an email account. The user then is presented with a short, six-frame tutorial which demonstrates how to use the application as it was designed to be used. Among several menu items, the "friends" tab enables users to add their Facebook friends or find them through their email contacts. The user can send and receive fitness challenges to and from their peers, track and post their progress to social media and over email, and see how they performed as compared to their peers through a custom leaderboard. The social engagement loop which encourages users to add their social media profiles, together with custom challenges, helps to facilitate onboarding by inviting friends and peers to join their personalized fitness network.

Table 1. Development considerations for a gamified mobile health (mHealth) application.

Design consideration	Description	Example
Mechanics are system-oriented and support, not undermine[26,27]	Mechanics should bolster the design of the application, not undermine	Greater emphasis is placed on gaining badges than tracking entry
Do not terminate a mechanic without informing the user[29]	Unless the application is for short-term intervention, mechanics used should not be removed nor should they cease in use or availability	Points and leveling should not stop or end because the user may feel they no longer need to use the application
Overemphasizing particular mechanics	Avoid excessively overusing one mechanic as compared to another, regardless of user demographic[10]	A robust points and leveling system with a very minimal, incomplete badging system
Design for the user demographic	User age and disease type should be considered in development	Older users may not prefer playful avatars as much as younger users

Bant features a social media feed "banter" which is similar to Twitter. Users can post blood glucose readings to the feed with the hashtag "#bgnow". It was found in the clinical pilot that adolescent children used banter to share the number of points they earned from taking blood glucose readings.[21]

Discussion

The use of gamification design principles in mHealth applications is yet a burgeoning innovations practice. As such, it is necessary to discuss design considerations. To do this, we use example from the literature regarding the efficacy of its application to chronic condition management, as well as other system that leverage these features for a more holistic health perspective. Limitations to the use of gamification in mHealth and suggestions for future studies will also be explored in some detail.

Design considerations

In developing a gamified mHealth application, it is recommended that several design considerations first be made (Table 1).

An example of mHealth application gamification efficacy

Presently, there is little evidence on the efficacy of mHealth applications that contain the mechanics of gamification. However, a pilot of bant with 20 adolescent children with type 1 diabetes showed nearly a 50% increase in the frequency of their daily measurements, although it cannot be shown the improvement was solely attributable to gamification.[21] Exit interviews indicated that the reward system was motivating to the participants.[21] As well, according to a recent myS-ugr usability engineering study with 20 type-1 diabetes participants, 95 percent (n = 19) were still actively using the application after 1 month, 90 percent (n = 18) after 2 months, and 85 percent (n = 17) after 3 months' use.[29] Although it has yet to be seen whether this application has the capacity to incentivize adherence over a longer period of time, the preliminary usability study data are promising. It is expected that, due to the relative novelty of gamification in mHealth, more studies will be conducted in the future, thus enabling further investigation into their efficacy at incentivizing behavior change. Building on the pilot, the next version of bant is

currently undergoing a multi-center RCT that builds on the reward system to also include leaderboards, and an expanded points and level system that rewards other self-care skills, such as resolving bouts of hyper or hypoglycemia.

Linking gaming with gamification in health and wellness

Although this work does not specifically detail the efficacy of gamified health systems and their mechanics in affecting improved self-management, the applications to the principles of gaming are detailed in Jane McGonigal's 2011 book *Reality is Broken: Why Games Make Us Better and How They Can Change the World.* In her book, McGonigal[30] argues four defining traits of a game, namely, that they are fun and provide a sense of purpose, they incorporate rules and thus command strategic thinking, they incorporate a feedback system which motivates users in achieving goals, and they are voluntary, which fosters a safe, relatively stress-free, and reassuring environment.[31] While the focus of her book regards the positive benefits of gaming, "SuperBetter," a gamified system also developed by McGonigal, contains applications of the examples discussed in her book. "SuperBetter" is available as both a computer-based and iPhone application. The system takes a holistic health approach in aiming to address physical, emotional, mental, and social health through the completion of a series of challenges.[31] Users are asked to provide their reason for using "SuperBetter," and given options such as "depression" or "anxiety," for which the system presents a series of quests, each of which the user can specify they completed by clicking an affirmative link with the text "I DID THIS!" For each quest the user indicates they completed, they are rewarded a point value for one of the four health metrics defined by the system, their progress bar for that metric then moves accordingly, and they progress closer to leveling-up. Each time the user levels-up, they are rewarded with new quests to complete, and new secret files—which provide the user insights regarding the principles of "SuperBetter."[31] Social engagement loops and onboarding enable users can build their "SuperBetter" networks by adding allies, and share their progress over social media.

"SuperBetter" utilizes most of the mechanics outlined in this article. Suffice to say, "SuperBetter," as an extension to McGonigal's book on the effectiveness of gaming in improving holistic health, is a practical example of how technologies may be designed for purposes of improving self-management for patients with chronic conditions.

Limitations

A literature review of "mHealth" and "gamifcation" and the iTunes store was used to search for examples of mHealth applications with gaming mechanics, therefore successful applications ported to other mHealth platforms, such as to Android or Blackberry devices, were not reviewed. Due to limited data availability around application download and installs, ranking the success of mHealth applications is largely contingent on consumer comments and reviews, which are subject to a host of biases, including application availability, pricing, marketing, and release date. iTunes Store application categories presently include "health & fitness" and "medical" search filters, so investigators must peruse various applications, and decide whether the applications they wish to review do, in fact, contain one or more of the mechanics outlined here. Some mechanics, as they were outlined by Zichermann and Cunningham,[10] may overlap in their implementation, so the investigator will have to decide how best to discern between them for purposes of exposition. Classifying the various mechanics of a gamified application can be subjective to the researcher's interpretation of the difference between the various mechanics, because there is no standardized

methodology for rating mHealth applications qualitatively, particularly as regards their successful implementation and use of gamification mechanics.

It is important to articulate that the applications selected for inclusion in this review were chosen on the basis of their being health-oriented and featuring gamification mechanics. As such, we do not suggest a relationship between their relative popularity in the iTunes store and their capacity to affect positive health outcomes. We do hypothesize that, given their use of gamification design principles, users are more likely to engage with these mHealth applications, thus incentivizing their continued self-management. As stated previously and reiterated here, literature on the very specific and recent application of gamification principles to mHealth, a burgeoning practice in itself, is limited. It is our intent that this review article emphasizes the importance of this practice and catalyzes further research into this domain.

Future work

In addition to the suggestions made above regarding follow-up or subsequent studies, there are numerous other areas in the domain of gamification that would benefit from further investigation. It would also be useful to determine, if possible, how effectively each of these mechanics map to user demographics, such as whether points and levels are more popular with younger users, or if leaderboards might be more popular with older users. Another area of interest would be to investigate the tactful use of serious games, such as true video games, in comparison to gamified applications as being more or less helpful in facilitating improved patient adherence. Furthermore, an investigation can be made into how best to contextualize the use of gamification mechanics to specific disease or condition type. Also, this domain would benefit greatly from some insights into how and why these mechanics pertain to those psychological factors that are important to adherence, and how best to leverage these mechanics to optimize the potential for patient adherence. Finally, the development of a framework for evaluating gamified mHealth applications would standardize further research.

Conclusion

Gamification mechanics are represented in several mHealth applications and are an encouraging implementation for incentivizing improved patient self-management. There were far fewer gamified mHealth applications available on the iTunes Store than would have initially been expected, though this is likely due to only the very recent use of these features in the context of healthcare as a patient engagement strategy. As mHealth application developers become increasingly privy to these concepts, it stands to reason that applications could be increasingly and better gamified, thus hopefully leading to improved patient self-management. While further research is required to discern the effects of gamification in the context of mHealth applications, the recommendations and popular mHealth application examples discussed in this article could be taken into consideration to design applications that have the potential to better incentivize and enable patient self-management of chronic conditions.

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to his accountability with regards to the accuracy and integrity of this work. Emily Seto contributed to the design of the review, providing analysis and extensive, iterative revisions, and conceptual support. She consents to the submission of the final article and has been made aware of and agrees to her accountability with regard to the accuracy and integrity of this work.

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