A Taxonomy for Digital Badge Design in Medical Technologies

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***Abstract*—This paper discusses gamification as an emerging area of research in medical health application development. It then defines digital badges as an example of gamification, explains their purpose and functionality, and outlines their primary advantages as well as ten different challenges impacting their use. This background is framed both generally and within the context of medical games and applications. The paper then reviews how digital badges and achievements are currently being used in medical games and healthcare applications. It concludes by synthesizing prior literature on effective game design and serious game design taxonomies with prior guidelines for effective digital badge design. The result is an interdisciplinary taxonomy combining research from serious games development, psychology, economics, user experience design, and education. This taxonomy can be reviewed to help researchers and developers consider a wide range of relevant issues when designing procedures for effective digital badge design and development in medical games and applications.**

Keywords—digital badges; achievements; healthcare; taxonomy; serious games; games; user experience; design strategies

I. INTRODUCTION

Some literature argues that games are useful in science education due to the interaction of game features with specific learner characteristics such as motivation, cognition, and metacognition [1]. Research in this field aspires to better understand relationships between instructional strategies, motivation, and learning outcomes [2]. However, such endeavors are complicated due to the diversity of different gaming constructs and the complexity of human learning in different domains. One strategy for making progress in this area is to identify the impact of game-like interactions on specific user activities. With this in mind, this article explores one gamified construct, the digital badge, and formulates a taxonomy of design recommendations for digital badge usage in healthcare and medical applications.

Before studying digital badges in more detail, however, it is useful to briefly review gamification and its relationship to medical technologies. Research is beginning to explore the specific relationships between gamification, health, and medicine. In a recent editorial, for example, Cugelman [3] discusses the suitability of such gamification tactics for digital health behavior change developers. Drawing from Hamari, Koivisto, and Sarsa [4], Cugelman [3] lists gamification tactics such as providing clear goals, offering a challenge, using levels, allocating points, showing progress, providing feedback, giving rewards, providing badges for achievements, showing game leaders, and giving a story or theme.

King et al. [5] discuss the importance of gamification for influencing health behaviors and predict that this method will continue to grow in popularity for two reasons. The first is the growing ubiquity of smart mobile devices that provide healthcare application developers with access to larger audiences, built-in hardware tools such as heartrate monitors accelerometers, and GPS technologies, and more attractive development tools for building hardware and software around these devices. Such mobile technologies have already demonstrated effectiveness at delivering health intervention programs such as smoking cessation and reminding users when to take their medicine [5]. The second reason for a predicted increase in popularity for gamification tactics is an enthusiasm in the development world for integrating the newest behavioral research into emerging healthcare products [5]. The authors explain that findings from psychology about how people make decisions are useful for understanding factors such as conditional rewards (e.g., points and prizes), loss aversion (e.g., trying to minimize undesirable outcomes during transactions), and endowment effects (e.g., irrationally valuing what individuals have over what they do not have). Such dimensions of psychology are important for gamification since many gamified technologies rely on these underlying psychological principles to function.

Crowdsourced data analysis is another area of opportunity for gamification in medicine. Crowdsourcing, or engaging large populations for data analysis, is desirable in medical technology because when done effectively, it can improve the quality, cost, and speed of research projects [6]. One success story in using crowdsourced gamification techniques for medical purposes is the crowdsourced online puzzle game Foldit. In this protein folding game, it has been suggested that gamification tactics such as rewards, points, and leaderboards have been critical for its success and popularity [7]. Cugelman [3] maintains that in order for such tactics to be effective, they must outperform other design patterns in their ability to influence beliefs, attitudes, and behaviors.

Such a strategy of performance analysis may be complicated when one considers that the field of medical

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technology is both diverse and distributed among different areas and disciplines [8]. This means that researchers often do not have a clear sense of existing design patterns and their effectiveness. To this end, it is perhaps more useful to more broadly consider the progression of medical technology creation from initial concept to final execution and identify where gamification tactics might be effectively embedded into such procedures.

When considering the pathway of innovative medical technologies, Yock et al. [9] explain that the innovation process generally matures through three stages: identification of needs, invention of concept, and implementation of strategy and planning. Each of these stages involves multiple steps and procedures. Identification of needs involves understanding the actual needs of end user audiences rather than simply what a designer expects them to need. This involves both end-user analysis as well as clinical, scientific, and market knowledge. Invention of concept focuses on developing a solution for this market using creativity and earlier, rougher versions of a technology (e.g., prototypes). The implementation phase then involves moving this technology from concept to execution. This stage incorporates everything from formulating a plan from research and development to developing strategies for clinical implementation, regulation, and quality assurance.

The purpose of this paper is to consider the first two phases of this innovation model – needs identification and concept invention – as they pertain to digital badges, also referred to as achievements within commercial video games. After defining digital badges and reviewing their use in medical games and applications, the paper then proposes a taxonomy for design that seeks to overcome the challenges and problems that emerge when using digital badges. Such taxonomies have been previously developed both in serious games at large [8] as well as in specialized contexts such as serious games for rehabilitation [10]. Other taxonomies have been used to collect and describe large collections of healthcare games used for particular purposes, such as games and simulations used in nursing education [11]. These taxonomies are useful for clarifying the many disparate elements that must be considered when designing new technologies for medical learning or healthcare training.

II. Methodology

This paper employs a qualitative approach to classify and identify themes from the digital badging literature to develop a theoretical guide for the development of badges in medical contexts. Methods of qualitative inquiry have been used in medicine and healthcare applications since the 1950s when ethnographies of medical students, mental patients, and doctors began to be published [12]. Qualitative research is now published regularly in the *British Medical Journal* and occasionally in the *New England Journal of Medicine* and *JAMA,* the *Journal of the American Medical Association* [12]. In Canada, the Institute of Qualitative Methodology (IIQM) was established in 1997 to support qualitative research and sponsor annual conferences for qualitative health researchers in North America [12]. Morse [12] notes that while qualitative methods are still not given the same status as quantitative methods, they are gaining ground as issues of quality and standards continue to improve for this type of research.

In order to propose a taxonomy for effective digital badge design in medical contexts, this paper synthesized literature from multiple areas. The paper's first task was to define digital badges and briefly outline some of their historical precursors. To locate relevant papers, *EBSCOHost, Academic Search Premiere,* the *ACM Digital Library*, and the *IEEE Xplore Digital Library* were searched using keywords such as "digital badges," "digital credentials," "achievements," and "gamification." Also critical to this portion of the literature review was the annotated bibliography curated by [13] and hosted by the Humanities, Arts, Science, and Technology Alliance and Collaboratory (HASTAC) as well as the MacArthur Foundation's web site on digital badges [14].

The next task was to describe the basic components of digital badges and define each component. This task used the same sources listed above, but with included keyword modifiers such as "components," "operational definitions," and "functions." These keywords led to a useful paper which divided badges into three primary components [15]. Following these definitions, the paper then argued for the usefulness of digital badges within medical applications and games and outlined many of the challenges that must be considered when planning and developing digital badges for healthcare purposes. Again, the same sources were used to review the literature, but additional keywords including "medicine," "healthcare," "health," and specific groups such as "physicians," "nurses," "healthcare providers," and "surgeons" were used to identify instances of digital badges used in health contexts. As expected, this literature review did not generate many sources, but there were some broader papers on health application gamification and innovative medical technology at large that proved useful for framing the taxonomy within this area of research.

The last task of the literature review was to generate a list of design recommendations useful for creating a taxonomy for digital badges to be used in medical contexts. Given the relative paucity of specific examples of digital badges and achievements in medicine as evidenced by the literature, the literature review first produced general guidelines for digital badges used to promote effective learning [16], such as the Design Principles Documentation Project, an initiative which studied 30 open badging initiatives from the 2012 Digital Media and Learning Badges Competition sponsored by the MacArthur Foundation [17]. This work was then considered in tandem with existing taxonomies for serious game design recommendations [8, 18], medical games [10], and commercial game achievements [19] as well as guidelines for innovative medical technologies [9].

Following this extensive literature review, qualitative, broad-stroke bucket coding was then used to categorize different design considerations from this prior work into themed categories (e.g. access, aesthetics, purpose, and so on). These design recommendations synthesize and combine prior research from serious games, medical technology

development, and digital badge design to propose a robust taxonomy that is useful for developers in the planning stage of a product who may wish to use digital badges to change player behaviors or provide credentials for completing major objectives.

III. Defining Digital Badges

This section of the paper defines digital badges, explores their usage and operation in video games and education, and considers their components. It focuses on ways in which digital badges are currently used for purposes such as motivation and credentialing. This paves the way for considering some of the specific challenges for using badging in healthcare, a topic covered in the next section. Many challenges apply to digital badging used for other purposes as well, but certain problems are exacerbated in healthcare contexts.

A. What are digital badges?

Digital badges are "validated indicator(s) of accomplishment, skill, quality, or interest" [20] that contain associated metadata such as captions or links that help display the context, meaning, or significance of an activity [21]. These digital badges act as "secondary reward systems" within the structure of an interactive environment in which players or users can complete optional goals and earn achievements that are then often displayed to other users or players within the system [22]. They are the digital equivalents of Scout Badges, military medals, and ornamental tokens work to demonstrate credibility or highlight special accomplishments [21].

Modern digital badges are often found in online systems such as massively open online courses (MOOCs) [23] and e-commerce where online vendors and users of products need visual indicators of reputation and credibility to display to Internet audiences [21]. Digital badges are used extensively online for various purposes, from rewards in geo-location games such as Foursquare and fitness devices like FitBit to markers of status and reputation for moderators and reviewers in online communities. They are particularly useful in informal learning contexts because they provide alternate mechanisms for recognizing the completion of activities that are structured in nontraditional ways [23].

Video games have long used their versions of digital badges, called achievements, to distribute trophies, points, and leaderboard rankings to players [19]. In these contexts, badges become interesting design tools since they can direct player behaviors in different sorts of ways for the purposes of additional exploration, performance enhancement, or increased time-on-task. A level designer might award players with achievements for particular accomplishments in speed, collecting, accuracy, sociability, and so on.

More recently, digital badges have been popularized in educational initiatives. One major factor behind this increased popularity was the development of the John D. and Catherine T. MacArthur's Foundation's competition for the development of "open" digital badges, a program that has since catalyzed more specialized forms of badges, such as badges for lifelong learning. Another likely reason for their popularity is their relatively modest resource requirements when used as a tool for gamification. As opposed to fully developed games and simulations, implementing a digital badging system is more straightforward and feasible. Finally, digital badges are useful for contemporary trends in policy initiatives for higher education. In the United States, for example, there is a movement toward eliminating or reducing seat-time requirements and creating more flexible arrangements for curricular accomplishment, such as competency-based learning [24].

In terms of their underlying mechanics and operation, badges have three main components: signifier, completion logic, and reward [15]. The signifier describes the aesthetic of the badge – its so-called "look and feel." The completion logic describes how a badge is earned, and the reward describes what is gained by earning the badge. For instance, in addition to displaying the virtual marker on one's web site, a badge earner might also earn points toward his or her participation grade or even some amount of currency which can be spent in real world or virtual storefronts. For example, some games, such as World of Warcraft, have communities where players can sell virtual items for real money; hard to obtain badges might hold similar value to dedicated players.

Even when digital badge rewards do not hold tangible real world value, though, there are often still significant psychological motivations for collecting and earning badges. Some of these motivations relate to established principles of social psychology [25] and behavioral economics [5].

B. Potential Advantages of Digital Badges in Medicine

Digital badges are beginning to appear in medical contexts such as surgery simulators [26] and are included as emerging technologies for new medical education paradigms [27]. These virtual tokens of accomplishment are useful in games and health applications for a number of reasons. For one, as previously noted, they are a method of gamification that is minimally resource intensive, requiring less development and implementation time than fully developed games or virtual worlds.

They are also pervasive markers of accomplishment that can be earned in one context, say an application or online course system, then displayed in another, say an online backpack such as might be found with Mozilla's Open Badges system. In this context, they serve as credentials for users that are useful for distinguishing one person from another, such as by noting a top commenter in a medical support forum.

Badges can also be used to encourage exploration. For instance, they are useful for redirecting user behaviors within applications is useful ways, such as redirecting a person playing the role of a doctor in a simulation to thoroughly speak with every patient rather than simply trying to reach the end of their rounds in the fastest possible time. This technique has been perfected in the world of commercial video games, where developers often use badges to increase the replayability of games and encourage additional effort and time on task from players. In this context, digital badges (e.g., game achievements) are thought to improve both the player experience and the quality of the game [19].

Badges used in this way can modify problematic behavioral patterns. For example, if sufficiently motivated to earn badges, individuals can be redirected toward specific activities by the ways in which badges are designed. A simple example is awarding a badge for visiting specific locations. This badge encourages individuals to move around outside their comfort zone and explore new places. When situated within a fitness game, such badges advocate for active lifestyles.

Another potential benefit of digital badges is their ethos of friendliness and accessibility. In terms of engaging young audiences, badges leverage familiar aesthetic and cultural tactics to engage young people. They are also touted as emerging technologies for informal learning in that they can provide a credentialing structure for activities that occur outside traditional academic boundaries. Many students grow up familiar with these technologies through experiences with video games. They understand how they work and they appreciate what is often a more casual and colloquial approach to learning that rewards their behaviors or performance.

Lastly, badges are flexible to outside models of credentialing. For example, a badge could be endorsed by third parties to indicate support; an example would be a national medical organization endorsing badges for fitness from health application or game designers. Similarly, within social media scenarios, badges serve a number of roles – functioning as technologies for instruction, reputation, status, group identification, and goal setting [25]. For example, many online social communities such as HealthUnlocked [28] use dynamic badges to indicate the current number of "likes" given by other users to posts within the community. This follows conventions from social media and web communities such as Digg, Facebook, and Reddit and provides a community-moderated status credential for user posts.

IV. Challenges for Digital Badges in Medicine

Although there are a numerous potential benefits to using digital badges, there are a number of issues that must be considered when implementing digital badges specifically for medical games or health applications. This is generally true of all medical technologies; as Yock et al. [9] note, designers of medical technologies often face significant barriers to success that arise in a number of areas including patents, regulatory approval, reimbursement, market dynamics, business fluctuations, competitive products, financing, clinical trials, and team dynamics, to name but a few. There are also specific physical demands which surround the medical profession, especially in specialized fields such as surgery. Prior research has argued that video gaming skill correlates with laparoscopic surgery performance and future games could be designed specifically with special considerations for fine motor skills useful for surgery such as hand-eye coordination, visual attention, and depth perception [29].

One useful approach to understanding the potential barriers for digital badging is to start with some of the more challenging or problematic implications, then consider how those elements should be considered during design and development. These problems can be divided into core areas representing various components of digital badges and organized around central themes as follows:

1. **Aesthetic challenges**. In their article about piloting a badge system at the Australian National University, Mewburn and colleagues [30] indicated that one early issue with their badging system was the "gimmicky" look of badges. Students earning the badges wanted them to reflect an ethos of hard work, not casual play. While this ties into issues of credibility, discussed separately, there are many other aesthetic challenges that must be addressed when designing badges. Badges that function well but look "boring" or uninspired will not carry the same weight, especially since the visual designs of digital badges are often compared to the achievements used in commercial video games.

2. **Cognitive challenges**. Badges that are not carefully designed with a player's thinking in mind can lead to problematic learning scenarios. These can be counterproductive, rewarding learners for undesirable activities.

3. **Credibility challenges**. When badges are used to incentive activities that have serious consequences, like impacting one's health, they may be seen as trivializing important topics that deserve a more serious and professional tone.

4. **Engagement challenges**. Some see gamification tactics such as digital badging as privileging simple, repeatable mechanics over deeper forms of engagement [31]. Such perspectives see badges more as a marketing gimmick than as serious tools for teaching and learning.

5. **Functional challenges.** These types of challenges encompass a variety of situations dealing with badge logics, from badges that are not unlocked when they are supposed to be to badges that are too difficult to obtain, and thus never seen.

6. **Motivational challenges**. Badges can potentially replace intrinsic motivation with extrinsic motivation, meaning that those activities normally seen as being rewarding in and of themselves are now pursued merely for the sake of earning a badge.

7. **Power structure challenges**. When previously unstructured activities become suddenly structured and there is an authority figure who is granting badges, attitudes or behaviors may be impacted in an undesirable way [32].

8. **Privacy challenges**. Depending on the criteria upon which badges are evaluated, there may be privacy concerns. This is particularly true when unknown third parties, such as employers or insurance companies, begin parsing badge collections and reviewing badges by individual or by aggregate group for specific purposes.

9. **Social challenges**. For badges that are designed to change the cognition, behaviors, or social interactions of players, incorrect design parameters can have adverse consequences. For instance, a badge designed to encourage socialization amongst players in a learning game could in fact do the opposite if earning such a badge was seen as a disincentive by players.

10. **Technological challenges**. There are not currently universal technologies for badging. This means that there are a number of technical complexities which may need to be negotiated before rolling out a system. Even once a system is designed and implemented, the badges students earn may be incompatible with other badging systems (sometimes by design, to encourage loyalty to specific systems).

Following the issues with badging identified in the literature, it is important to further consider the specialized domains of medicine and healthcare. These fields add additional layers of complexity to medical badging, for a number of reasons. Privacy of sensitive information is one such concern. Healthcare information is often sensitive and subject to specific laws which limit the disclosure of healthcare information without explicit consent from the patient. For example, in the United States, the Health Insurance Portability and Accountability Act of 1996 (HIPAA) sets "national standards for the security of electronic protected health information" [33].

Ethical issues within medicine can also pose both opportunities complications for digital badge design. Yock et al. [9] review the American Medical Association's Principles of Medical Ethics which pose holistic and comprehensive guidelines for physicians' ethical responsibilities to patients. Such guidelines include safeguards for confidentiality and privacy, respect for patient rights, a dedication to competent care, a focus on upholding the standards of professionalism and honesty, a commitment to sharing relevant and accurate information, a commitment to enhancing public health, and a mandate to support access to medical care for all people.

Opportunities for badges relating to such guidelines are found in the commitment to communities and public health; one can imagine how fitness badges, public health engagement badges, and healthy eating applications would serve this role within communities. On the other hand, the obligations to safeguard sensitive data and ensure accurate content pose challenges to personalized health games and applications that use the human body as a source of data. In these types of scenarios, designers and developers must be extra careful to protect this information and secure appropriate permissions and consent from participants.

Given such issues with the medical technologies that surround highly sensitive patent information, one approach to digital badging in health applications can be found in fitness games and games and applications designed for weight loss. Such configurations often depend upon players being able to translate between real world and virtual domains. For example, Berkovsky et al. [34] describes a game in which players can earn rewards by performing physical activities that could then be traded for advantages within a game. After performing a user study with 180 participants, the authors concluded that young players could be motivated to engage in physical fitness activities while playing games and that players did not decrease their enjoyment of the gaming activities as a result of such effort. While these authors did not study badges explicitly, the link between the virtual and the physical, as well as the impact of rewarded behaviors, are certainly relevant to similar issues faced with digital badges.

V. Examples of Digital Badges in Healthcare and Medicine

Despite these challenges and complexities, there is growing evidence of digital badges used gainfully within medical games and simulation technologies. Mehta et al. [27] describe badges as one of a number of "disruptive innovations" in medical education with the potential to transform how learning occurs. The authors note that digital badges rely upon metadata that provide detailed information such as the recipient's name, the endorser or organization providing the badge, the task completed and criteria met to earn the badge. One important aspect of badges noted by these researchers is that "they reflect mastery of real-life skills and are valued by employers looking for evidence of expertise not often reflected by college degrees." They also note that many medical students have grown up with technology and are likely already familiar and comfortable with badges.

Medical schools in the United States are also beginning to explore digital badges within the context of continuing education, research, and professional development. For example, the University of Michigan's Medical School [35] uses badges to credential participants who complete a course on technology development, an initiative wrapped up within a larger badging program for their Office of Research. They use the Credly.com system [36] to award and distribute badges, allowing for display on social media sites such as LinkedIn, Facebook, and Twitter. In addition, the Credly badges earned by participants can be added to an online résumé or displayed in an email signature line. Boston University's School of Medicine [37] uses a similar digital badging program which offers asynchronous access to online materials that are accessible to both practicing and retired health care professionals in teaching roles.

In terms of more specific medical training, Esteban et al. [26] report on efforts integrating a haptic virtual reality (VR) medical simulator with Moodle Badges, an implementation of digital badges that displayed user progress and provided markers of accomplishment. In this implementation, when the simulation users completed a simulation with satisfactory performance, they were awarded course badges within Moodle. These badges could then be exported to other systems, such as Mozilla Open Badges, and potentially displayed by the learners on their own personal web sites or professional repositories.

Perhaps the most significant use of digital badges in the healthcare domain, however, is within the field of fitness and

healthy eating applications. For example, Lose It! [38] is a popular weight loss application that awards digital badges to participants based on both incremental weight loss goals as well as user persistence in logging calories and eating healthy meals. Similarly, The Y-MVP Teen Fitness Challenge is organized by the New York YMCA [39] and uses digital badges to encourage teens to adopt healthy habits. Teens register for an eight-week course, complete challenges, and enroll in fitness "missions" that allow them to earn accomplishments and display them on social media, timelines, and leaderboards.

The Nike+ application similarly rewards players for participating in fitness activities while also allowing users to compete toward challenges using social networks to recruit competitors. Here, digital badges function as motivational tools, icons for achievement and recognition, and sharable objects within existing technology systems [40]. There are many other examples of health applications such as Keas, Work.com, Earndit, Zamzee, FitBit, Endomondo, and Sports-Tracker [7], many of which use badges and other gamification tactics to reward users and redirect behaviors toward desirable patterns of activity.

VI. Toward a Taxonomy for Digital Badges

Following the points raised by considering the challenging issues articulated above and exploring some of the existing uses of badges in medicine and healthcare, this paper proposes a taxonomy for designing medical badges that uses the following criteria to describe badges and their potential use. Such a taxonomy combines research from designing achievements for commercial video games [19], guidelines for effective learning with digital badges [16], other taxonomies for serious games [18] and for specialized games used in medical contexts [10], and general guidelines for developing effective and innovative medical technologies [9].

The interdisciplinary design taxonomy is outlined in this section. The taxonomy is intended to be used in the planning and implementation stages of a medical digital badge design project. Each category includes associated guiding questions or research notes that should be considered when designing a badging system. For example, when considering the design of a badging system, it is important to carefully consider the audience, difficulty, economics, leveling, and so forth, of the system. Many questions are also relevant to the design of the individual badges described and deployed by the system. While many of these factors will apply to many different types of badging systems, it is likely that some categories will be more useful and relevant than others, depending on the particulars of implementation and audience for a given project.

These categories are described below and the guiding questions and notes are included within the description of each category.

Access. Who will have access to earn badges? Similarly, who will have access to view badges, once they are earned? In medical applications, such questions are often challenging. Patient consent to release sensitive information might be required in certain contexts, depending on the particular nature of the badges and how they are earned.

Aesthetics. While aesthetics could certainly be broken down into a number of categories, one way of defining aesthetics would be through the tone and artistic style of badges. For example, one might follow a more cartoonish, humorous style for a childrens' health game, or a more formal, official style for a badging system designed for adult participants.

Application Area. Derived from Rego, Moreira, and Reis [10], this criterion considers the domain of a given badge, or the context in which it is used. For example, in their taxonomy [10], common domains include both cognitive rehabilitation and physical/motor rehabilitation. Since this badging taxonomy is considering all areas of medicine and healthcare as potential domain areas, the application areas can be vast. What is important to note is that the particular application area will dictate the terms of many other design factors. The types of badges most suitable for art therapy games may not be ideal for cognitive rehabilitation games.

Audience. Similar to application area, game and application audiences are also important to consider during development. Age group is one important factor for serious games [18] and is similarly important to consider for badge design. Other factors include gender as well as demographics such as socioeconomic status, ethnicity, and culture. A children's game focused on teaching young female learners about healthy eating and nutrition will likely implement very different badges than a simulator designed to help veterans deal with post-traumatic stress disorder. For some audiences, the potential drawbacks of badges may even outweigh the potential benefits. Because of this, audience identification is something that should be considered in the early stages of design.

Difficulty. The level of difficulty for earning badges impacts the player experience in a number of ways. Challenging badges might be seen as desirable, for instance, or they function as disincentives if they are perceived as being too challenging.

Economics. What economic models drive badge acquisition and motivate players to earn badges? What rewards will be distributed for earning badges and how will those rewards be given value inside and outside of the game? Economics might also refer to social economic outcomes, such as bragging rights or reputation enhancement.

Learning Content. How will badges be used to recognize, assess, motivate, and study different types of learning within medical games or applications? Such a question is complex and a full treatment is outside the scope of this paper. However, interested readers should consult Hickey [16] which provides a full report on these factors as well as Ratan and Ritterfeld [18] who consider educational content and serious games.

Leveling. Will badges use tiered or leveled mechanics, wherein a user might earn a badge and then unlock additional tiers of that badge as progress continues? A simple example is a digital badge that is unlocked and then augmented with gold stars as additional proficiency is achieved.

Openness. Will the digital badges use an open framework, or a proprietary system? A major benefit of an open system is interoperability between different badging implementations [41]. A benefit of a proprietary system is additional control and customization that can be used to tailor a badge program for a very specific purpose. In contrast to the next dimension of the taxonomy, privacy, openness refers to the possibilities for data exchange between computer systems.

Privacy. In contrast to openness, which refers to computer software interoperability, privacy refers to the ability for humans to access potentially sensitive information describing other humans. How will user or patient privacy be handled and how will confidential information be separated from publically available information? Are there privacy implications for the sharing of badges, such as the use of leaderboards or a shared badge repository?

Purpose. Are badges used to promote exploration, for credentialing, reward, redirection, or some other purpose?

Sociality. How will badges utilize social mechanics? Will badges connect to social media applications, such as Facebook and Twitter? Can badges be earned collaboratively, with multiple players or users working together? Might badges be competitive, and, if so, will scarcity mean that only certain players can earn certain badges, and that once these badges are earned, they are no longer attainable by other players? Such questions raise interesting behavioral, cognitive, and ethical questions. The popular device FitBit has experimented with competitive social badging; for example, challenges such as Weekend Warrior pit players against one another to see who can take the most steps.

Technology. Which technology will be used to display the badges and/or analyze badge data once they are deployed? Rego, Moreira, and Reis [10] define the user dimension of this as the "interaction technology," or the technology used by the patient (or healthcare professional) to interact with the system. Badges may be distributed using a video game, application, or simulation. This might also include issues such as console or platform, a primary identifying characteristic identified in the classification of serious games [18]. After the technology used to award badges is selected, there is also the additional issue of the technology used to access badge data and look for patterns in user behaviors. Both the awarding and analysis technology may be the same, but they may also be different and involve customized plug-ins, data scrapers, or programming scripts that are customized to particular clinical or research needs.

Visibility. Will badges be immediately visible, or will some be hidden from users? This design decision will impact how players interact with a system.

VII. Conclusion

This paper presented a preliminary, interdisciplinary taxonomy that raises key questions about designing medical badges for health games and applications. It is expected that such a taxonomy will continue to be refined over time as new issues emerge that speak to effective design strategies for medical technologies. Drawing from both research in commercial video games and the academic scholarship, the paper argued that digital badges within healthcare are challenging for a number of reasons and such design guidelines are critical for consideration during both needs analysis and concept invention, the first two phases of the innovation pipeline described by [9].

This type of taxonomical analysis is also useful for better understanding the impact of digital games and gamification strategies on player performance, learning, and motivation. For example, while there is overlap between some of the gamification tactics mentioned in [4] at this paper's introduction, a granular level of consideration is important given that research studies evaluating the impact of games often lump "game-based learning" into a single category and then compare it against non-game-based methods [42]. This is a disservice to games given the broad number of genres, technologies, strategies, and conventions used by different games designed for different purposes. Taking a single gamification strategy, such as digital badging, and exploring it in detail is a productive first step in better understanding the many factors that impact how these technologies are reacted to and used by professional health care providers, patients, and the general public.

Future research should continue to investigate digital badges in medicine by generating empirical data testing such badges for specific purposes in specific contexts. For instance, researchers need to better understand how socially earned and shared badges motivate other users in a system to pursue fitness activities. Similarly, the design community need to better understand both patient and physician attitudes toward such technologies.

As badges continue to move toward wider adoption in the medical and healthcare fields, it will be important for developers and practitioners to work together and follow best practices for the design and implementation of effective and sustainable badge architectures. Initiatives such as the Badge Alliance [20], a collaborative initiative between both corporations, universities, and nonprofit agencies, are useful for providing both vision and recommendations for technical specifications. Developers choosing to implement badges for medicine should be aware of this network and the resources it provides.

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