Gamification and Serious Games in a Healthcare Informatics Context

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***Abstract*—The objective of this literature overview paper is to inform the healthcare informatics reader, who is new to gameful design, and introduce him or her into the domain of serious games and gamification for health. This paper aims to inspire readers by a lower level description of the opportunities offered by gameful design and apply it in the healthcare informatics domain. Furthermore, to ensure that gameful design apps are well implemented, designers and researchers of these technologies need to understand the mechanisms of gameful design and tailor gamification mechanics accordingly. Based on this literature overview, we propose design guidelines researchers can use to implement gameful design in their healthcare informatics projects.**

***Index Terms*—gamification, motivation, healthcare informatics**

I. Introduction

Play, games, and game-inspired design is no longer reserved to the domain of mere entertainment. In the past decades, gameful designs have been promoted to achieve various goals beyond fun and pleasure. For example, there is a long-standing tradition of employing video-games for *edutainment* [1], learning or training [1]–[3]. Such games that do not have entertainment, enjoyment or fun as their primary purpose are labeled *serious games* [4]–[6].

Nowadays, applications such as LinkedIn and StackOverflow are well known for using simple game design elements like points, badges, levels, and leaderboards to motivate their users. This use of game design elements in non-game contexts quickly became known as *gamification* [7]. Many companies emerged to offer gamification design or complete packages [8] to integrate game design elements into existing applications. Domains with successful gamification projects range from learning analytics, employee engagement, heritage, crowdsourcing, civic engagement, marketing, tourism, and health [9].

In the past years we have witnessed a surge of gameful design specifically in the domain of health [10], using gameful designs to assess disease status, rehabilitate psycho/motor functions or even motivate to adhere to healthy behaviors [11]–[14]. Besides assessment, training and rehabilitation, gameful designs aim to motivate players to sustain healthy behaviors. Whatever the health focus, the underlying premise of gameful design is that by tapping into what makes games fun, users are intrinsically motivated to train or change behaviors [15].

In this paper we will zoom in on the important literature, and further dissect the concepts of *serious games* versus *gamification*, specifically for the healthcare informatics domain. The outline of this paper is as follows: in the second section, we will first focus on better understanding games and play. In the third section we will shed light on serious games with a focus on health. In the fourth section we will zoom in on gamification. In the fifth section we will argue that while serious games and gamification are clearly different, they share an underlying conceptualization of tapping into intrinsic motivations. In the sixth section we will focus on user personalities for getting gameful design right, be it serious games or gamification. Finally, we propose design guidelines targeted to the healthcare informatics community.

II. Defining Games and Play

In order to discuss gameful design, we first need to discuss what is meant with *game* or *play*. Huizinga, the first to speak of *Homo Ludens* [16], defines play as: "*a voluntary activity, standing consciously outside ordinary life as not serious, but at the same time absorbing the player intensely and utterly. It is an activity with no material interest, and no profit can be gained by it. It proceeds within its own proper boundaries of time and space and according to fixed rules and in an*

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orderly manner. It promotes the formation of social groupings which tend to surround themselves with secrecy and stress their difference from the common world by disguise or by other means."

One thing that is apparent in all rhetorics on games and play, be it video games or more traditional types of play, is the *paradox of play*. Deterding et al. [7] make the division between *playing* and *gaming*. "*Whereas paidia (or 'playing') denotes a more free-form, expressive improvisational, even 'tumultuous' recombination of behaviors and meanings, ludus (or 'gaming') captures playing structured by rules and competitive strife toward goals.*" [7] Huizinga, emphasized that *"although play is non-serious and not real, at the same time play demands order, absolute and supreme*." [16] In a similar vein, Bernard Suit defined play as: *"The voluntary effort to overcome unnecessary obstacles." [17]*

Notice that *games* and *play* are often used interchangeably but that somewhere there is a shift in meaning between these two concepts. When reviewing the literature, we notice that while the concept of play seems to address more the make-believe nature, the concept of games emphasizes the rule-based nature [18]. Salen & Zimmerman take a different stance toward the distinction between games and play and argue that the *play of a game* is the experiential aspect of a game: *"Rules are set into motion and experienced by the players."* [19]

Presently, most game scholars agree that games and play involve both interaction, constrained by rules and necessitated by goals, and immersive fantasies, afforded by the artificial audio-visual game world and the narrative of the game. The intertwining of fantasy and rules are also captured in Juul's observation that digital games are *half-real* [20]. With this observation, Juul provides an elegant solution for the apparent *paradox of play*. The rules are real because they define how to play the game. Winning or losing is a real event as players feel emotionally attached to the outcome. Compared to Huizinga, Juul's focus is less on the act of playing and more on play (or games) as a formal system. Play is considered to be an artefact that can be designed.

Today, a well-accepted and more practical definition for games is offered by Juul, and consists of six parts:

1. *A game is a rule-based system;* a game has clear rules about how to play, about which player actions are allowed, and which are not.
2. *It has variable and quantifiable outcomes;* different possible outcomes are possible as a result of the player actions.
3. *Different outcomes are assigned different values;* there are win-states and loose-states, not all outcomes are equally valuable.
4. *The player exerts effort in order to influence the outcome;* challenges are provided and the player's actions result in different game outcomes.
5. *The player feels emotionally attached to the outcome;* the player does care about attaining the win-state or not.
6. *The consequences of the activity are optional and negotiable;* winning in a game is without consequences in real life.

III. Serious games in Health

The previous section presented a definition of games in general. In this section we will zoom in on how serious games extend the realm of games and play and particularly for health.

A. Defining serious games

An initial definition of serious games is provided by Abt [4] who presents simulations and games to improve education, both in and outside of the classroom. Sawyer [6] redefined the definition of the *Serious Game* with the Serious Games Initiative in 2002. Finally, Chen & Michael [21] define serious games as "*Games that do not have entertainment, enjoyment or fun as their primary purpose.*"

From the above definitions, an attentive reader may remark that serious games seem to violate the last criteria offered by Juul. After all, the ambition of serious games is exactly to make an impact beyond the game itself. However, note that normally, this is not directly tied to the win or lose state of a game. Players can lose a game but nevertheless gain psycho-motor skills, or become more motivated to sustain a certain health behavior. This is also shown in Figure 1.

B. Serious games for health

Originally, serious games were used most often within a game-based learning setting (often labeled pejoratively as *edutainment*) [1]–[3] or with a specific commercial objective, such as promoting brand awareness (*advertainment*). However, already in mid-1980 it was noted that games could be used for measurement and training of psycho-motor skills [13], [14].

In the past decade, we witnessed a surge in gameful designs in health. In 2006, Hopelab released Re-Mission [22], a video game that motivated teenagers diagnosed with cancer to adhere to their medication scheme. An RCT study with 600 youngsters showed the effectiveness of the game on self-efficacy, and ultimately disease control [23]. This study was carried out with the highest standards of scientific rigor and showcased the opportunities of games for health to a wider public. In a series of studies, Green and Bavelier [12], [24] found that action video game play is associated with superior perceptual and cognitive abilities, and that playing active fast-paced video games can improve visual attention skills. More recently, Anguera et al. [11] published groundbreaking work in Nature, showing that that video game training can enhance cognitive control in older adults.

Wattanasoontorn et al. [10] classify serious games for health by player, and by disease status. For example, serious games targeting patients could focus on health monitoring, treatment/therapy, rehabilitation, or self-care. Non-patient serious games focus primarily on health and well-being, and both professional and recreational training.

A systematic review by Primack et al [25] showed the potential promise for video games to improve health outcomes,

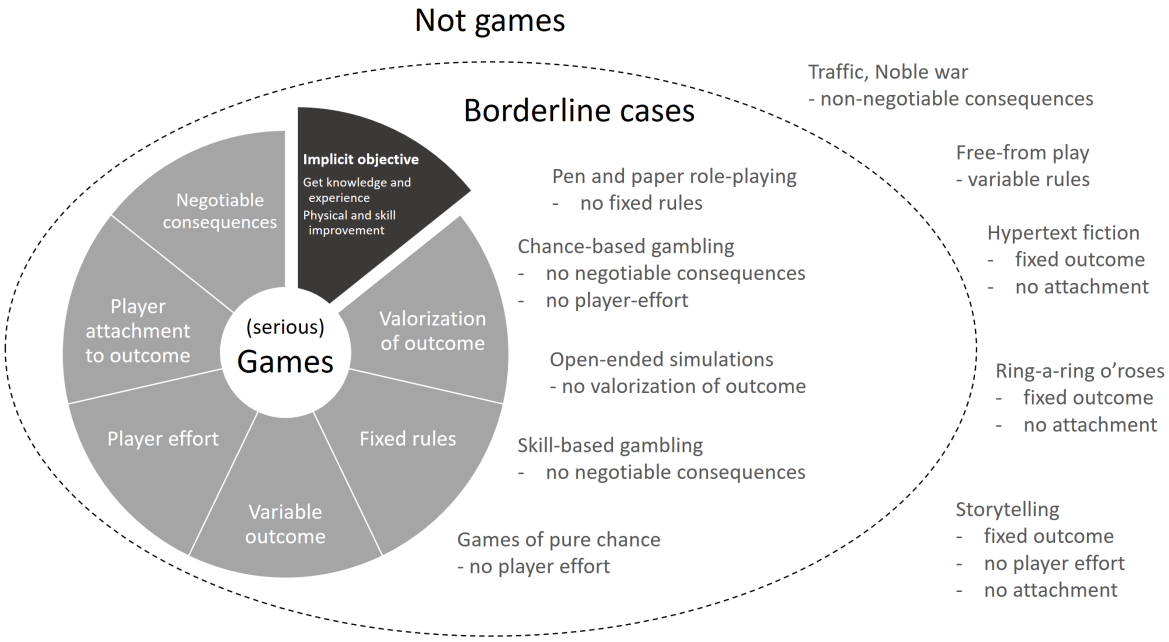

Fig. 1. Implicit objective integrated in Juul's model as an additional part of a serious game [10]. Image strongly based on [20] and parts from [10].

particularly in the areas of psychological therapy and physical therapy. Lau et al. [26]'s findings from a newer systematic review suggest that serious gaming interventions may be effective for reducing disorder-related symptoms. However, they also claim that more studies are needed in order to attain deeper knowledge of the efficacy for specific mental disorders and the longer-term effects of this new type of treatment for mental disorders. Finally, in another systematic review Meijer et al. [27] found that serious games seem a safe alternative or addition to conventional physiotherapy after traumatic bone and soft tissue injury. They claim that future research should determine their validity and effectiveness in rehabilitation therapy, next to their cost-effectiveness and effect on treatment adherence.

IV. Gamification in Health

Not all gameful design includes full blown serious games. Sometimes, only parts of an application are 'gamified'.

A. Defining gamification

The most widely-used formal definition of gamification is "*the use of game design elements in non-game contexts,*" as proffered by Deterding [7] in 2011. Gamification is about harnessing the motivational affordances of gameful experiences to influence psychological outcomes and further behavioral outcomes [28]. Effective gamification is a combination of game design, behavioral economics, motivational psychology, and user experience [29]. If implemented well, gamification can increase the motivation of user's trajectories [30], [31].

Designers typically integrate gamification into their product or service to increase user engagement. Other authors, such as Werbach [32], offered other definitions to gamification. For example, "*gamification is the process of making activities more game-like.*" [32] Werbach argues that Deterding's definition is valuable in many ways, but the concepts of *game design elements* and *non-game contexts* are contestable and can cause for confusion [32]. Figure 2 shows the thin line between serious games and gamification.

B. Game design elements vs gamification mechanics

Distinct visions exist on what game design elements (or game mechanics [34]) are. In this paper, we follow Deterding's vision who states that game design elements are elements that are characteristic for games, rather than full-fledged games [7]. They are "*[a] distinct set of rules that dictate the outcome of interactions within the system. They have an input, a process and an output.*" [35] For example, a *point* in itself is not a game element. However, the system that rewards points based on some predetermined rules can be considered a game element or mechanic.

When game design elements are used outside the domain of full-fledged games and used in a non-game context, they are also referred to as gamification mechanics [35], [36]. Robson et al. [36] state that "*mechanics are the decisions that designers - those who wish to gamify a non-game context - make to specify the goals, the rules, the setting, the context, the types of interactions, i.e., opponents, and the boundaries of the situation to be gamified.*" However, authors often use both terms interchangeably [8], [36]–[39].

Although both gamification and serious games try to motivate the user and enhance their experience, *they are not the same*. Gamification is the use of specific game design elements in a non-gaming context [7], while serious games are complete games. In the end, the difference lies with the presence or

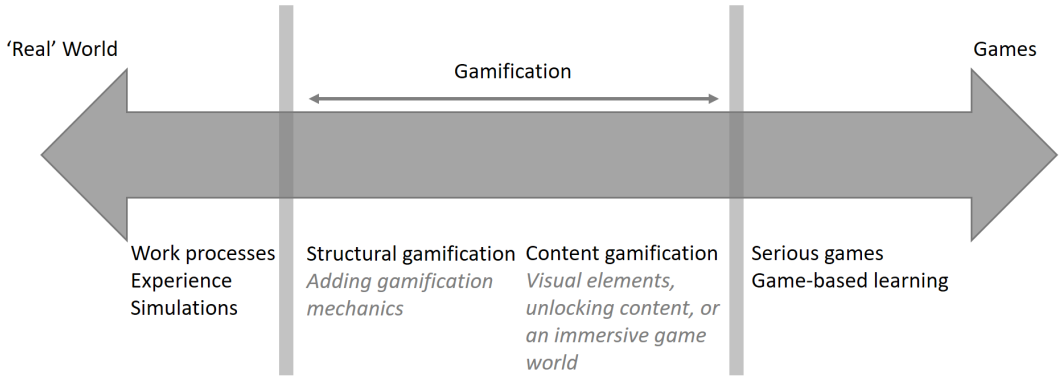

Fig. 2. The gamification continuum. Image based on [33]

absence of game play. A gamified application is not a game in itself. In contrast, a serious game "*has all the elements of a real game, will look and feel like a real game, but has some defined purpose, outcome or message the creators wish to get across to you.*" [40]

There is not one exhaustive taxonomy or list of gamification mechanics. However, an elaborate and useful framework is provided by Chou [41] in his Octalysis framework. He states that there are eight different types of core drives that motivates us to do certain activities. Other authors/organizations also compiled a list with gamification mechanics. The enumeration below is only a small set of available gamification mechanics collections.

- NICE describes "*10 game mechanics with the power to engage [...] employees.*" [42]
- Bunchball [43] proposes ten primary gamification mechanics that can be used "*to accomplish business goals.*"
- Mythily and Herger present a "*curated list of game mechanics that may be used as building blocks and combined in strategic ways to achieve the positive engagement loop in your application.*" [44]
- Marczewski compiled a list of 52 gamification inspiration cards [45].
- Tondello et al. [46] present a "*model of eight groups of gameful design elements in three categories: individual motivations [...]; external motivations [...]; and social motivations.*"

C. Systematic Reviews of Gamification in Healthcare

Johnson et al. [47] found that the current state of evidence supports that gamification can have a positive impact in health and well-being, particularly for health behaviors. However, several of the studies they included also report mixed or neutral effect. Findings need to be interpreted with caution due to the relatively small number of studies and methodological limitations of many studies. Sardi et al. [48] claim in their systematic review that there is a need for further empirical evaluations to provide a rigorous validity of gamification's effectiveness in healthcare. They found, however, that the most frequently investigated conditions are chronic disease management and physical activity. Concerning game mechanics, most of the studies Sardi et al. [48] reviewed reported that rewards, feedback and socialization aspects are recurrently used.

Unfortunately, according to Edwards et al. [49], few health apps currently employ gamification in a meaningful way. There is a wide variation in the use of behavior change techniques, which may limit potential to improve health outcomes [49]. However, crucial issues need to be analyzed in depth if the full potential of gamification is to be harnessed [48]. Heterogeneous study designs and typically small sample sizes highlight the need for further research in both gamified training and testing [50]. Finally, further research is required to evaluate effective behavior change techniques and to assess clinical outcomes [49]. Nevertheless, careful application of gamification can provide a way to develop engaging and yet scientifically valid gamified applications. We argue that this paper can help designers and researchers to reach this goal.

D. Gamification pitfalls

The concept of gamification has received much attention but also much critique [51] for taking into account only a narrow perspective of what makes games fun and engaging.

One of the first conceptualizations of gamification (and by now a subdomain of gamification) is pointsification, also known as PBL (points, badges, leaderboards) [52]. Pointsification uses point-based gamification mechanics: points are assigned to users when they complete a given task, or they are assigned badges or certificates once they achieved a given score; leaderboards are used to rank the different users to a create a 'gamified' process [53].

While pointsification is a great tool for communicating progress and acknowledging effort, but neither points nor badges in any way constitute a game. For example, "*[d]eciding to run two miles today rather than one, or drink two liters of Coke instead of four are just choices of quantity. Deciding to dump my sniper rifle for an energy sword is a meaningful choice.*" [54] Without the importance of meaningful choices when introducing gamification you are just helping the user

to understand quantities. People are more likely to adhere to autonomous and internalized behaviors when they can self-identify or connect with goals that are meaningful for them [55]. Someone who has integrated the activity with his or her goals is more likely to see the activity as positive than if there is external control integrated with the activity [56].

V. Motivational design techniques

While gamified applications are clearly different from serious games, they share the same underlying premise, tapping into the intrinsic motivation of players.

A. Intrinsic Motivation

Many perspectives, theories, and models are addressed in the topic of motivation. Sailer et al. [15] discuss six perspectives which are the foundation of gamification mechanics:

1. *A behavioristic perspective* in which positive reinforcement plays a role.
2. *A cognitive perspective* in which internal considerations between expectations and values are considered.
3. *A self-determination perspective* where the user tries to satisfy basic human needs for autonomy, solidarity and competence.
4. *A trait perspective* in which the combination of stable, individual character traits such as need for status or security are considered.
5. *An interest perspective* where the user searches for interest and challenge.
6. *An emotion regulation perspective* where the users tries to promote positive and reduce negative feeling.

In addition to these classic motivational psychology perspectives, the gamification literature also includes models from social psychology, e.g., Cialdini's [57] influence perspectives: authority, reciprocity, sympathy, consistency, and scarcity.

When broadly interpreted, serious games and gamification techniques can be considered as applying motivational design techniques. Both techniques allow their users to experience the satisfaction of psychological needs [37], [58]. However, the concept of motivational design techniques is broader than the application of gamification mechanics and serious games.

B. Self-determination theory

Motivational affordances are often used to facilitate intrinsic motivations as advocated by self-determination theory (SDT, see Figure 3) [59]. While on the basis of the aforementioned list of Sailer, SDT is only one specific perspective on understanding motivational perspectives, it has gained much traction within the field of gameful design. Ritcher et al. [60] consider gamification as "*the application of extrinsic motivators. Careful selection and implementation of these motivators will trigger internal motivation and aid in maintaining it.*" Hence, we deem it important to further detail this theory. SDT claims that all people have three basic psychological needs. These needs are innate and universal. These needs should be met in order to feel mentally and physically healthy. They should also be met in order to enjoy a certain behavior and become intrinsically motivated.

1. *Autonomy* is defined as the "*need to be the perceived origin of choice of one's own behavior, acting from one's own interests and values.*" [62]. Autonomy expresses that we all need to perceive that we have choices and control over our actions. We need to experience a behavior as volitional and reflectively self-endorsed.
2. *Competence* is defined as "*the need to feel effective one's ongoing interaction with the social environment and experiencing opportunities to exercise and express one's capacities*." [62] Competence reflects the need to perceive that we are good at something. Competence involves feeling efficient, effective, and mastery. Competence is not the same as skill or capability. In fact, people might, from an outside perspective, not be very good at a task. They can, however, still feel competence themselves if they feel confident to perform the task at a certain level, and if they feel they are improving. It is about the perceived sense of mastery.
3. Finally, *relatedness* is defined as "*the need to feel connected to others, to care for and be cared for by those others, to have a sense of belonginess both with other individuals and with one's community." [62]* We have a need to perceive that we are connected to others via positive relationships. We have a desire to know where we fit in the group and feel meaningfully connected to others, rather than feeling alienated.

VI. User personality

Not only a user's intrinsic motivation should be considered when implementing a gamified system or serious game, personality matters too. All individuals have reasons why they act, think, behave and feel in a certain way at different stages of their life [63]. Not everybody is motivated by the same elements. Research shows that personality affects player types [64], player preferences or genres [65] and motivational affordances [66]. Personality can also affect how players experience psychological satisfaction in games [67]. It is therefore important to use gamification mechanics that consider the different personalities or personalize the system.

A. User Types based on Gameplay

Bartle's player type model is one of the earliest models [68]. Bartle identified four player types for players of Multi-User Dungeons (MUDs): 1) Achiever, who aims to obtain some level of success; 2) Explorer, who seeks out the thrill of discovery; 3) Socialiser, who is attracted to the social aspects; and 4) Killer, who enjoys the competitive elements of the game.

To include a wider perspective regarding player types, Bateman and Boon adopted the Myers-Briggs Type Indicator [69] to games and proposed the first *Demographic*

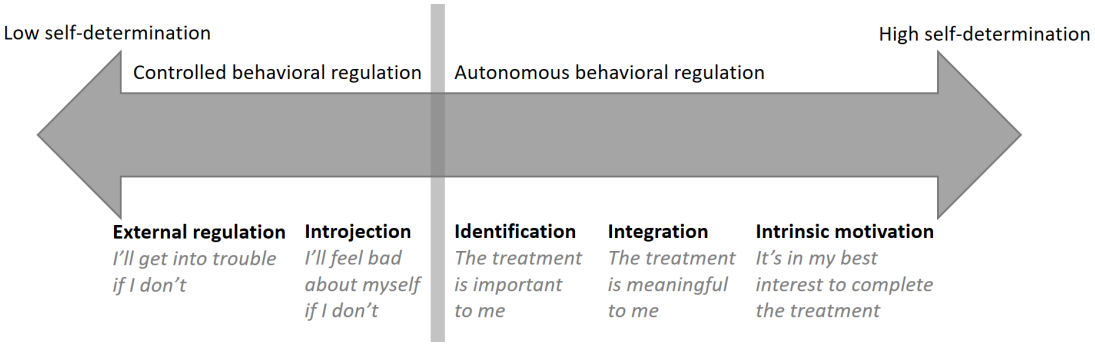

Fig. 3. The Self-Determination Theory continuum. Image based on [61]

Game Design model (DGD1) [70]. This model was later updated to the second Demographic Game Design Model [71]: 1) Conqueror, is actively interested in winning and beating the game; 2) Manager, is generally looking for a strategic or tactical challenge; 3) Wanderer, is a player in search of a fun experience; and 4) Participant, all other players.

B. User Types based on Data

The *BrainHex* model [72] is based on previous player typologies (and others) and neurobiological research. It is a hypothetical model, "*and exists primarily to further the investigation of possible traits that could be used for the construction of a more robust future model.*" [72] It introduces seven player types:

1. Achiever, explicitly goal-oriented, motivated by long-term achievements
2. Conqueror, enjoy defeating impossibly difficult foes, struggling until they achieve victory, and beating other players.
3. Daredevil, the excitement of risk taking and generally playing on the edge
4. Mastermind, enjoy solving puzzles, devising strategies, and making the most efficient decisions.
5. Seeker, curious about the game world and enjoys moments of wonder.
6. Socialiser, people are a primary source of enjoyment, they like talking to them, they like helping them, they like hanging around with people they trust.
7. Survivor. enjoy the intensity of the terror experience, at least within the context of fictional activities.

Marczewski proposed the *hexad model* [73]. Rather than basing the model on observed behavior, the user types are personifications of people's intrinsic and extrinsic motivations, as defined by SDT [62]. Figure 4 illustrates the six user types from the hexad model:

1. Philanthropists, are motivated by purpose. They are altruistic and willing to give without expecting a reward.
2. Socializers, are motivated by relatedness. They want to interact with others and create social connections.
3. Free Spirits, are motivated by autonomy, meaning freedom to express themselves and act without external control. They like to create and explore within a system.
4. Achievers, are motivated by competence. They seek to progress within a system by completing tasks, or prove themselves by tackling difficult challenges.
5. Players, are motivated by extrinsic rewards. They will do whatever to earn a reward within a system, independently of the type of the activity.
6. Disruptors, are motivated by the triggering of change.

Fig. 4. The six user types as proposed by Marczewski. Image taken from [73]

VII. Player-Centered Design

While combining a serious and entertaining goal is already ambitious, the specific scientific rigor necessary to validate health games further complicates successful commercialization of serious games or gamified applications. All too often this results in in typical tensions and dynamics as described in [74]. Designing a serious game for health or gamified application often includes large-scale, software development with a multidisciplinary team, spanning arts, engineering and biomedical sciences. Furthermore, as aforementioned, it is important to take into account that not all users are identical. It is therefore important to involve the user, or player, as quickly

as possible into the design process to document the differences and to devise strategies.

To mitigate some of these challenges, researchers have proposed a player-centered design [75] process, as a subdomain of user-centered design. One such framework is P-III, a player-centered, iterative, interdisciplinary and integrated framework. This framework has been developed over the course of five years of research on the design and development of serious games. Hence, P-III is built bottom-up, molded and shaped, tested and refined through several research projects [30], [76]–[79].

VIII. Gamification analytics

An additional opportunity to adapt to different players is to track the user's activities [80]. Any action the user makes can potentially be captured, i.e., low level data such as button presses and taps to gamification interaction. Gamification metrics are then interpretable measures, based on this tracked data [81]. Hence, the user actions such as taps on user interface elements still need to be interpreted in light of specific gamification states. Which metrics to record and how to transform and interpret data depends on the specific gamification strategies chosen and that lend themselves to this tracking.

Heilbrunn et al. [82] define gamification analytics as "*the data-driven processes of monitoring and adapting gamification designs.*" Gamification experts have agreed that these activities are crucial to the long-term success of gamification projects [83]. The aspect of implementing gamification mechanics in software applications is well supported by gamification platforms such as Bunchball, Badgeville, or the SAP gamification Platform [84]–[86]. However, the use of specialized tools to monitor and adapt gamification designs is not common [87]. Instead, customized, narrowly focused solutions for reporting purposes are common. Those solutions are often expensive to implement and maintain. gamification analytics have thus not yet received significant attention from academics nor from a practical perspective. Herzig et al. [85] proposed a gamification process model of four phases: 1) Business Modelling and Requirements, 2) Design Workflow, 3) Implementation, 4) Monitoring and Adaptation. Heilbrunn et al. [82] built on this model and added gamification analytics.

This problem has also been addressed in different domain. In learning analytics, for example, different approaches have been proposed to model this behavioral information [88]. When tracking gamification activities, the granularity should be considered. A first approach focuses on low-level events such as touches, swipe gestures, and selections. A second approach focuses on higher-level events such as actual activities of the user. An example is answering a question. Current standardization initiatives in learning analytics like IMS Caliper [89] and xAPI [90] already focus on these high-level activities.

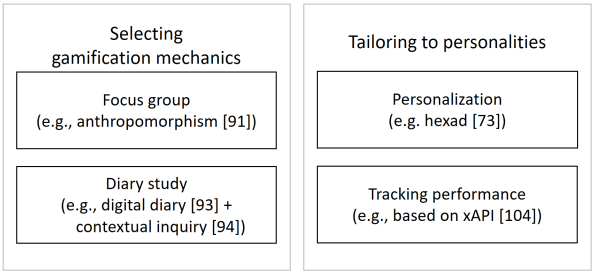

Fig. 5. Overview of the proposed guidelines to help designers and researchers select, personalize, and tailor gameful design in their serious game for health or gamification healthcare application.

IX. Gameful design guidelines

Based on this literature overview, we discuss design guidelines designers and researches can follow to design a serious game for health or to introduce gamification in a healthcare application. The guidelines consist of two topics as shown in Figure 5: selecting gamification mechanics and tailoring to personalities.

A. Selecting gamification mechanics

It is not straightforward to determine the right gamification mechanics. Existing taxonomies, such as described in Section IV, might help the designer. However, these are not tailored to healthcare applications. We therefore designed two protocols to help designers and researchers select appropriate gamification mechanics in a healthcare informatics context.

1) Focus group protocol: To assist designers and researchers in the healthcare informatics domain select which gamification mechanics can be applied in their gamified application, we developed a focus group protocol [91] that can be used with both patients and caregivers to select suitable gamification mechanics in an eHealth or well-being context. The overall goal of the proposed focus group protocol is to determine:

1. Which issues patients experience when they use an eHealth application.
2. Which motivational strategies are appropriate and which gamification mechanics are suitable to help patients reach the goals of the app.
3. How to personalize and make use of the context to optimize the use of these mechanics.

The proposed protocol builds on the Anthropomorphism approach as proposed by Vandenberghe and Slegers [92] and starts from the idea that users are tempted to humanize technology and software. This method introduces the metaphor of an all-knowing, omnipotent virtual supercoach who can, and wants to, do everything to motivate participants. Thanks to this abstraction, participants might be stimulated to think about the future and ideal use of the telemonitoring platform, without having full insights into sensor or gamification mechanics, or personalization techniques such as recommender algorithms. The full focus group protocol can be found in [91].

2) Diary study: To help understand the targeted end-user, or player, we propose to perform a digital diary study based on the work of Matthews and Doherty [93]. We advocate to use the existing platform (or application to be gamified) to enable users to maintain a digital diary. As this approach assumes users are already using the application that the designers want to gamify, the threshold to maintain a diary is likely lower.

After a certain period, the researcher or designer should visit the participant for a semi-structured in-depth interview. This semi-structured in-depth interview could be conducted according to the Contextual Inquiry method as defined by Beyer & Holtzblatt [94]. This method, which is common in design research, can be regarded as a specific interpretation of the Grounded Theory approach [95] in the sense that there is no a priori theoretical framework that directs the interviews. The contextual inquiry method is based on a combination of semi-structured interviews and user observations and is based on four principles: context, partnership, interpretation, and flexible focus. The researcher therefore visits the participant to conduct a final in-depth interview in a familiar environment.

B. Tailoring to personalities

Hamari et al. [28] has shown that gamification is not a panacea. As shown in Section VI, different user groups and personality types necessitate different gamification mechanics [64], [96], [97]. Where some users may be motivated by competition and leaderboards, other users may be discouraged by competitive elements [15]. Whereas some users may be encouraged by challenges and quests, others may dislike the strong focus on achievement. Hence, there is a need for intelligence with respect to which gamification mechanics are appropriate for specific personality types and user groups [98]. Careful consideration is needed to select, track, and personalize a set of gamification mechanics.

1) Personalization: As mentioned in Section VI, there are different models to classify the user's type. Within a healthcare context, the hexad model is a good candidate [99]. Tondello et al. [97] created a validated survey to determine the user's hexad type. Furthermore, Orji et al. [100] analyzed how the big five emotions relate to the hexad user types. The distribution of someone's big five emotions can be determined in multiple ways. Users can fill in a full questionnaire [101], a shortened questionnaire [102], or even let algorithms analyze their social media feeds [103].

We built on Marczewski's 52 gamification mechanics [45] to let help designers pick suitable gamification mechanics. Figure 6 shows an example of three cards. In this English version, Marczewski's original text is used and augmented with a visual example. However, both the text and the visual example should be translated/adapted to integrate the context of the target application.

2) Tracking performance: A gamification analytics shell can track gamification metrics, i.e., interactions of patients with the telemonitoring platform and game-elements such as leaderboards, experience points, performance graphs, as well as adherence metrics. Adherence metrics are those user

Fig. 6. Three example gamification mechanics, based on Marczewski [45].

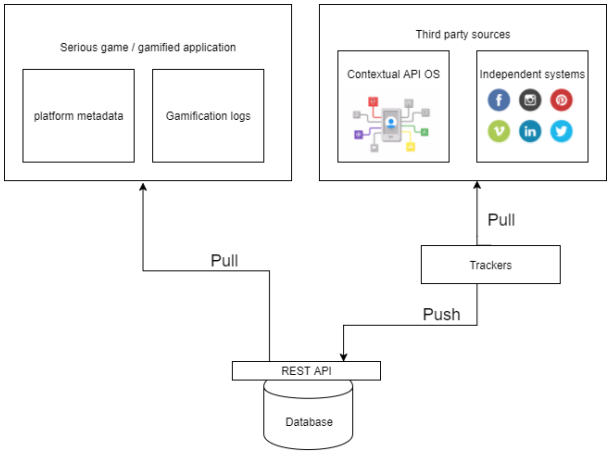

Fig. 7. Different components of a potential tracking architecture based on Santos et al.'s framework [104].

actions that can be indicative of adherence such as retention versus churn, daily active usage, session length. They allow to observe and log the success of gamification mechanics. They can also help to understand the user's behavior and how users use the gamification mechanics.

Part of understanding gamification mechanics is collecting and analyzing gamification related data. As explained in Section VI this problem has already been addressed in other domains such as learning analytics. A potential architecture based on Santos et al.'s framework [104] to track gamification metrics as is shown in Figure 7.

By logging and analyzing gamification data, we can gain more insights, so we can take considered action towards the achieved goal. Relevant data sources comprise user behavior data, user properties, and gamification data. User behavior data describes user actions, e.g., opening a badge to see why it is earned. User properties describe known properties of the users, e.g., gender or geographical location. Finally, gamification data represents gamification mechanic-related information, comprising the gamification state and user progression over time.

X. Limitations and Future Work

Two limitations of this study should be acknowledged. First, the proposed guidelines have not been evaluated formally with patients yet. However, the objective of our future work is to

investigate whether the combination of gamification mechanics and context-aware recommender techniques can increase the motivation of people to adhere to telemonitoring actions as part of their therapy. And hence, whether these 'intelligent' gamification mechanics can reduce drop out. To maximize the effect of telemonitoring, it is important patients are motivated (and kept motivated) to adhere to their therapy. We will therefore use these guidelines and protocols to study this case study. Furthermore, consortium partners in the ITEA - Panacea Gaming Platform[1] project will also use these guidelines and protocols to research how to integrate gameful design in their healthcare applications.

Second, this literature review study does not follow a strict systematic review protocol. However, we argue it is also important to discuss and agglomerate the main research papers in this field. In a recent systematic review of Machado et al. [105] it became clear that developers are selecting interventions that are endorsed by guidelines, although their quality remains low. There are many projects available, but their effectiveness in improving patient outcomes has not been rigorously assessed. Researchers and developers need to work closely with healthcare professionals, researchers, and patients to ensure app content is accurate, evidence based, and engaging. However, it can be hard for a non-expert to understand the difference between all the concepts in the gamification domain.

XI. Conclusion

In this paper we presented an overview of the concepts and definitions of games and play, serious games in health, and gamification applied to the healthcare informatics domain. Furthermore, we discussed motivational design techniques and how to personalize gamification mechanics to individual users. Based on this research, we propose gameful design guidelines (as summarized in Figure 5) to help designers and researchers select gamification mechanics, differentiate between different user personalities, and tailor their experience to the individual users.

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