GAMIFICATION APPLIED FOR HEALTH PROMOTION: DOES IT REALLY FOSTER LONG-TERM ENGAGEMENT? A SCOPING REVIEW

Research paper

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Abstract

Gamification is a popular design approach with the purpose to increase engagement and continuous use of Health Behaviour Change Support Systems (HBCSS) with the purpose to establish health and well-being. It is widely employed for promoting healthier life choices or for supporting people with chronic diseases in their daily activities. Yet, there is a lack of evidence concerning gamification and its ability to sustain favourable effects on health behaviour change. This paper presents a scoping review about the long-term perspective in gamified HBCSS, focusing primarily on IT-reliant systems that treat individual lifestyle habits like healthy nutrition, exercise or smoking cessation. We systematically selected studies that consider gamified HBCSS for health promotion and discuss to what extent long-term engagement is explicitly included in their design. Our results underline a deficit of consideration of the long-term perspective as well as a lack of measurement related to the lasting effects of gamification. We therefore propose to intensify the use of longitudinal and prospective observational studies in the context of HBCSS, in order to increase the level of evidence of gamification interventions.

Keywords: Gamification, Health Behaviour Change Support Systems, Long-term engagement.

1 Introduction

Gamification transposes game mechanisms and elements to non-game contexts as a way to motivate people, initiate participating processes and improve user experiences (Deterding et al., 2011). Badges, rewards or social competitions are thereby employed to orient and positively influence individuals' motivation, behaviour and/or productivity (Deterding et al., 2011; Huotari and Hamari, 2012; Blohm and Leimeister, 2013).

Popular among marketing, production, and learning environments (Deterding et al., 2011; Seaborn and Fels, 2015; Nacke and Deterding, 2017), gamification is obtaining great attention in the area of healthcare as well (King et al., 2013; Pereira et al., 2014; Johnson et al., 2016). Evidence suggests that gamification rises enjoyment, engagement and compliance of health-related activities, while positively impacting health outcomes and cost of service delivery (Lenihan, 2012; Pereira et al., 2014). Its implementation is reinforced by the development of advanced digital health platforms, built around ecosystems of wearable and mobile devices, such as fitness trackers or other sensing devices like smartphones (Thiebes et al., 2014; Rapp, 2017). Whether these digital services are conceived to enhance individuals' well-being, guide rehabilitation periods or assist patients in their disease management, gamification holds great potential for adding further positive experiences to their primary health-related goals (Alahäivälä and Oinas-Kukkonen, 2016; Sardi et al., 2017).

These digital services can be referred to as *Health behaviour change support systems (HBCSS)* when their aim is to alter individuals' attitude and behaviour toward wellbeing and healthier lifestyles (Mettler, 2015; Alahäivälä and Oinas-Kukkonen, 2016). In such cases, gamification is mostly applied for encouraging individuals to continue using the service in a more regular manner, or facilitating and promoting the completion of certain health-related activities which are associated with a positive behaviour (Alahäivälä and Oinas-Kukkonen, 2016). A major assumption of gamification in HBCSS is therefore that human behaviour and attitudes can be positively influenced through technological interventions (Hamari et al., 2014). That said, these attitudes and behaviours need to be maintained over time in order to lead (if at all) to *concrete* and *positive* outcomes in terms of health and well-being (Bandura, 2004; Klasnja et al., 2009; Mettler, 2015). In this sense, the temporal dimension inside gamification is of utmost importance. Yet, long-term effects induced by gamification for digital health and, specifically, HBCSS are insufficiently explored and understood. Johnson, et al. (2016) and Sardi et al. (2017) identified the long-term viability of gamified health services to be a major challenge. Likewise, Cugelman (2013) showed that scholars frequently report difficulties to express if outcomes represent sustainable long-term impacts on health, or just elusive short-term effects. Accordingly, this paper aims to develop an exploratory study regarding the long-term engagement in digital health behaviour change interventions, and concentrate, as an initial approach, on systems designed for health promotion. To this end, we set out to investigate the following research question:

RQ: How do studies on health promotion through gamified systems account for the long-term aspects?

The remainder of this paper is structured as follows. After explaining *gamification* in more detail, we then describe our methodological approach in reviewing the extant research. This is followed by the examination of gamification approaches in HBCSS together with the investigation of how long-term engagement and temporal considerations are included in the identified literature. We conclude with a reflection on the practical and theoretical implications of our study, as well as an indication of the limits of our work and some propositions to guide future research.

2 Conceptualizing gamification in HBCSS

Gamification is frequently understood as the use of game design elements in non-game contexts (Deterding et al., 2011) or as the process of enhancing services with motivational affordances for "gameful" experiences (Hamari, 2013; Hamari et al., 2014; Alahäivälä and Oinas-Kukkonen, 2016; Schmidt-Kraepelin et al., 2018). Gamification therefore corresponds to a mechanism with game characteristics that tries to positively influence one's personal motivation and/or perception about a selected action so that it is more engaging. It notably involves supporting user engagement and

enhancing positive patterns in service use, such as increasing user activity, boosting social interaction, or raising quality and productivity of actions (Hamari, 2013; Hamari et al., 2014).

In order to appreciate how these gamification mechanisms are deployed, it is first of all necessary to understand that the notion of game is not the main object of the system: it is only a means to support and lead to a certain behaviour (Ryan and Deci, 2000; Deterding et al., 2011; Darejeh and Salim, 2016). That also grants the differentiation between gamification and serious games (Deterding et al., 2011; Sailer et al., 2017). In fact, serious games utilize gaming as a central and primary medium (Fleming et al., 2017): they are fully-developed games serving a specific and non-entertainment purpose (Deterding et al., 2011; Xu et al., 2013; Mettler and Pinto, 2015; Sailer et al., 2017). Gamification, on other hand, contains some game components but does not present a fully virtual game environment nor fulfil a game experience where the user can completely immerge himself (Fleming et al., 2017). Furthermore, in contrast to game-based technologies that include engines or controllers, gamification designs typically only involve game references. Hence, game design elements (or gamification elements) are defined as those elements that are characteristic of games, that can be found in most (but not necessarily all) games, and that are meaningful to the sense of the game and the gameplay (Deterding et al., 2011; Deterding et al., 2011; Sailer et al., 2017). Put in other words, they constitute features implemented to add some hedonic element(s), in order to support the completion of an utilitarian purpose (Hamari et al., 2014).

Gamification elements are diverse and materialize in different forms (e.g. points, badges, levels, leaderboards etc.). However, only reasoning in terms of gamification elements (without context attention) and presuming their effects on motivation seems rather speculative (Cugelman, 2013; Alahäivälä and Oinas-Kukkonen, 2016). We shall not, for instance, simply suppose that *points* motivate users. In fact, we also have to consider the persuasive strategies that the *point* fulfils; take in account the value that a community places on that *point* and weighing the value that the individual himself bases on the *point* (Cugelman, 2013). Hence, calling on (successful) gamification requires a deep comprehension of the contextual factors, and the same goes for any analysis of gamification mechanisms. Gamification elements therefore relate to gamification strategies. Hence, an element is implemented with regard to a plan of action, especially when it targets a behaviour change. For instance, a popular gamification strategy is enhancing motivation by indicating success (Sardi et al., 2017). *Points, badges, achievements*, or *statuses* typically provide the path to its application. Adding a feedback to increase interest and/or positive attitudes in completing a given action forms another common strategy. Gamification may also refer to a form of competition, by setting challenges, creating confrontations and making the effort visible to other users (e.g. via *leaderboards, performance graphs* or *rankings*) (Lister et al., 2014; Park and Bae, 2014; Sailer et al., 2017; Sardi et al., 2017). Likewise, gamification can rely on social dimensions: the design therefore consists in enhancing participation (while completing the task) by group dynamics, interactions through a social network and exchanges with a given community (Pereira et al., 2014). *Narrative storylines, avatar-based self-representation, onboarding tutorials* (Cugelman, 2013; Sardi et al., 2017; Yassaee and Mettler, 2017), as well as *theme* and *clear goals* (Hamari et al., 2014; Johnson et al., 2016) serve as additional gamification design elements. These latter also bring up the importance of the game design experience. Aesthetics are critical and might be the guarantor of the success of a gamified process (e.g. the quality of the technological depiction is essential in a virtual representation of a character). Plus, in everyday life, individuals are more and more accustomed to a certain quality of digital products and services: adoption of high quality gamified schemes is therefore crucial (Pereira et al., 2014).

When used for developing HBCSS, gamification strategies are similar to approaches and purposes of persuasive technologies: they aim, throughout artefacts, to induce behaviour change (Kappen and Orji, 2017). In order to characterize them, we adopt Cugelman's taxonomy for digital health behaviour change (2013). It is, to our knowledge, the first research that provides a tested framework in the area of gamification for digital health behaviour change interventions. *Table 1* illustrates the retained gamification strategies and game design elements. By the same token, it summarizes the development presented in this section.

Gamification strategies			
1. Goal setting		5. Capacity to overcome challenges	
2. Providing feedback on performance		6. Reinforcement	
3. Compare progress		7. Social connectivity	
4. Fun and playfulness			
Game design elements			
1. Points	4. Rewards	7. Achievements/Badges	9. Levels
2. Story/Themes	5. Clear goals	8. Feedback	10. Leaderboards
3. Progress	6. Challenge		

Table 1. Framework explaining gamification strategies and game design elements for digital health behaviour change

Principal application areas of gamified HBCSS are the promotion of physical activity, guidance in nutrition, as well as supporting chronic disease management and rehabilitation (Johnson et al., 2016; Sardi et al., 2017). In fact, three major groups of use contexts can be differentiated:

A. *Individual lifestyle habits*. Operating on weight control, food consumption, eating habits, exercise, physical activity, unhealthy habits (e.g. smoking) and hand hygiene can be labelled as a function on lifestyle habits, where advanced gamified systems reinforce positive experiences and support individuals to adopt beneficial health behaviours (Pereira et al., 2014; Alahäivälä and Oinas-Kukkonen, 2016). Pereira et al. (2014) thereby mention that gamification contains the ability to transform the obstacles (that may lead to behavioural changes, such as failure) into engaging, positively reinforcing and perhaps even fun experiences that encourage users to make sound decisions and activate the desired behaviour for the benefit of their health and wellness.
B. *Chronic disease management and rehabilitation.* Chronic disease management (e.g. diabetes, cancer, Alzheimer's disease, stroke and obesity) and rehabilitation respond to the presence of a given condition. Thus, gamification offers great opportunities in guiding patients through their treatment, making the procedure more engaging and facilitating new forms of self-management. The objective is therefore to establish an effective chronic disease management, in the interest of improving positive health outcomes (Cafazzo et al., 2012; Miller et al., 2014).
C. *Support of health professionals*. Lastly, gamified digital systems are also developed in order to support health professionals in their education and their daily tasks. The goal is to enhance their engagement and cooperation, notably by easing (or making more enjoyable) the practice of medicine, which often involves tedious, repetitive, boring, and/or painful routines for both the practitioner and patient (Pereira et al., 2014; Alahäivälä and Oinas-Kukkonen, 2016).

That being said, Alahäivälä and Oinas-Kukkonen (2016) additionally stress the importance of reflecting about the user context (*Is there a targeted group of users? Who composes the majority of potential users?*), the technological context (*What is the technological support or modality that is being employed?*) or other contextual factors that practitioners, designers, and scholars need take into consideration in order to (successfully) design or analyse gamified systems for health behaviour change.

In sum, we presented a description of gamification and stressed the importance to apprehend game design elements, gamification strategies, as well as contexts all together to evaluate gamified HBCSS and put them on the challenge of time.

3 *Opening the way* to conceptualize *a* long-term perspective in gamified HBCSS

As mentioned before, HBCSS inherently ask for long-term engagement in order to act on behavioural intentions and attitudes that potentially lead to positive health outcomes (Bandura, 2004; Klasnja et al., 2009; Mettler, 2015). In view of the lack of theoretical evidence about long-term engagement in digital health, a *scoping review* of literature is necessary to explore the extent situation. This form of review provides the opportunity to map a body of literature that might be composite and understudied, as well as determine potential research possibilities (Grant and Booth, 2009). However, as we have seen, gamification for digital health can be employed in several contexts, i.e. (1) maximising wellness, well-being and quality of life (health promotion), (2) restraining and managing an existent disease (rehabilitations processes and disease management) or (3) providing education for health professionals (Stuifbergen et al., 2010). For our scoping review we chose to concentrate on gamified systems for individual lifestyles habits (1), given that the situational context and end-user in the other two cases are much different. To be more precise, we excluded (3) because the use of IT-reliant systems in a professional setting is very different from a private setting (e.g. it could be mandated by management). Although relating to individual users in private settings, we excluded (2) because use intention and expectation of users could significantly differ and as such the long-term mechanisms. For gamified systems designed for health promotion, *wellness* appears to be the first focus, whereas *illness* serves as frame of reference and finds itself in the background. Gamified systems for rehabilitation or chronic disease management function the other way around: the primary target is *illness*, and *wellness* is a perspective in the background (Stuifbergen et al., 2010). Motivation and long-term engagement are in both cases challenges to address; however, it may appear much harder to motivate people that only have a perspective of *illness*, than patients that face the *illness* and are in treatment or rehabilitation. For these reasons, and in order to ensure coherence, we only selected a single stream of research for this paper, namely health promotion.

Additionally, long-term engagement and continuous use can surely be considered as relative concepts. What are, for instance, the frontiers when considering that gamification has achieved a long-term use and, therefore, that a health behaviour is adopted? Can it be rightfully claimed that the long-term use starts at one point and finishes at another? What is certain is that this subject seems insufficiently investigated. Again, regarding the lack of theoretical evidence, we decide to draw on our retained papers to see how they apprehended concepts like *long-time use* or *continuous engagement*. We therefore expand on the research methods applied in gamification for HBCSS: we formulate the assumption that longitudinal studies (frequent and continuous measurements to observe a particular cohort) and follow-up interventions provide reliable data about continuous use. As a matter of fact, longitudinal studies employ frequent and continuous measurements to observe a particular cohort over a long period of time (Caruana et al., 2015). Besides, we argue that any follow-up that is distinctly detached from the initial/main intervention, assures to capture some actual post-intervention effects. Our hypothesis is that these constitute the best approaches to evidence a long-term perspective, at least at this scoping phase of research. In our view, cross-sectional study designs (i.e. measuring engagement only once) offer weak evidence to explain long-term engagement, as it simply does not allow for causal inferences. Given the number of identified studies, we will still take this type of studies into account (although their contributions will be considered with caution) in order to provide a categorization and to investigate the evidence level of extant research. The purpose of this paper is to deepen the reflection about the temporal ("long-term") perspective and engagement.

4 Methods

To address our research goal, we first perform a systematic search of scholarly articles that explicitly dealt with digital health promotion and gamification. We then categorize the retained literature using our previously described framework (cf. Table 1), evaluate how gamification (or the gamification mechanisms employed) cope with long-term engagement and summarize our findings with a promising value proposition with respect to motivation and participation on the long run. Figure 1 depicts the study selection process in the form of a PRISMA flow diagram (Moher et al., 2009).

In concrete terms, we determine, as a first step, keywords that are directly related to gamification. The selected terms *gamification OR gamif* OR gameful* intuitively refer to gamification and ensure inclusion of multiple variations of the term, like (to) gamify or (being) gamified (Deterding et al., 2011; Johnson et al., 2016). They also utterly align with the recent systematic literature reviews linked to gamification and health (Alahäivälä and Oinas-Kukkonen, 2016; Johnson et al., 2016; Sardi et al., 2017). In addition, we take into consideration the following terms: *health* OR wellbeing OR well-being* to potentially include relevant studies associated to health, well-being and behaviour change. Our search is performed in the following abstract and citation databases: *Scopus, EBSCOHost, Web of Science* and *ACM Digital library*. These platforms offer electronic access to multiple databases that reference cross-disciplinary research. The prior mentioned search terms are employed for all fields (including title, abstract, keywords and full text), and all result types were reviewed.

Inclusion criteria for studies are: (1) written in English; (2) published on a peer-reviewed venue; (3) available in its full form; (4) clearly defines methodology of the study; (5) clearly refers to gamification; (6) clearly refers to health digital devices and services. Papers excluded from the review belong to at least one of the following categories: (1) only reports specific chronic condition management; (2) briefly mentions gamification but the actual substance is not gamification-related; (3) mentions health digital services and devices but the core is not related to them; (4) mentions persuasive technologies but does not actually study a topic connected with such technologies; (5) work-in-progress papers, study protocols and study prototypes. Accordingly, our review retains all the articles that explicitly refer to gamification (as defined in *Section 2*), automatically excluding serious games, video games and other applied games. In the same vein, papers that do not clearly relate to some sort of digital intervention (e.g. using mobile or wearable devices) are not considered, given that we are evaluating the use of gamification in digital health devices and services.

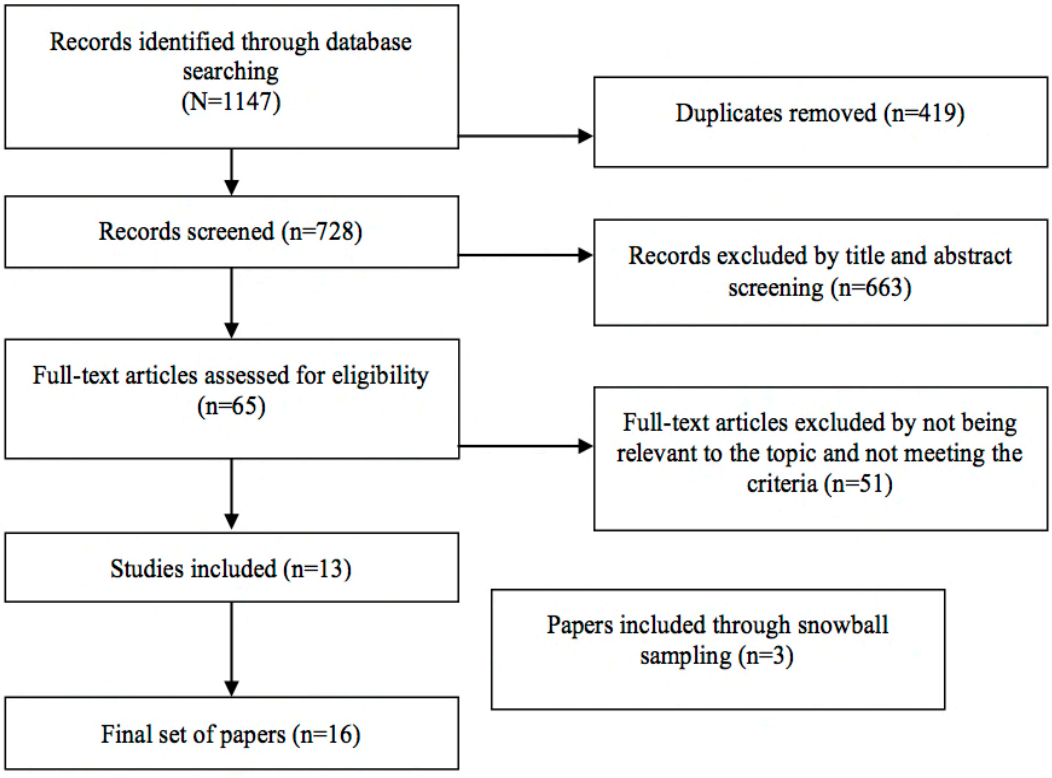

Figure 1. PRISMA flow chart for the selection of studies.

We qualitatively analysed our final set of papers with regard to the meaning of "*long-time use"* and "*continuous engagement",* as well as in relation to research methods applied for studying longitudinal or future effects. The research methods applied in the studies are presented in the *Results* section *(See Section 5)* and the approaches regarding the long-term perspective are presented in the *Discussion (See Section 6).*

5 Results

Our initial database search identified a large number of papers (N=1147), out of which 419 were duplicates. After removing those, we screened the remaining 728 papers by title and abstract. After excluding another 663 papers, a total of 65 papers were considered for a full text evaluation. Among these, 13 were found to meet our criteria. The most frequent reasons not to include papers were notably the use of gamification for managing a particular health condition, as well as the strong presence of studies that did not provide any empirical evidence (but rather only conceptual considerations or technical design recommendations). Following the guidelines provided by Wohlin (2014), we added three more articles to our analysis by using the snowballing technique. In consequence, a total of 16 papers were retained for comprehensive analysis. The selected papers are detailed in *Table 2*, along with the reported gamification approach (see *Section 2* for our classification modalities) and research design.

A vast majority of the retained papers (9 out of 16) focus on rising physical activity through gamification. Interventions, within this categorization, range from encouraging children to adopt an active travel to school (Coombes and Jones, 2016), to improving commitment in sports tracking software (Giannakis et al., 2013). The second most common context of use can be labelled as *enhancing eating habits*, i.e. acting on school kids' fruit and vegetable consumption (Jones et al., 2014). Such a distribution is not really surprising, if we consider studies that report gamification for health and well-being: in that respect, gamification for behaviour change toward healthier habits is essentially linked with increasing physical activities and, to a lesser extent, improving nutrition (Alahäivälä and Oinas-Kukkonen, 2016; Johnson et al., 2016; Sardi et al., 2017). The remaining four papers related to smoking cessation (El-Hilly et al., 2016), sleeping habits (Ilhan et al., 2016), health consciousness (Ogi et al., 2015), or stretching exercises (Kim et al., 2017).

The systems reported in the literature often make use of several gamification elements and strategies in parallel (cf. *Table 1*) Only one of them (Giannakis et al., 2013) exclusively relies upon one single element (*feedback*) and subsequently activate one particular strategy (*providing feedback on performance*). In this precise case, gamification is used to provide some visual data, in order to stimulate and motivate users to optimize their performance. Still, as our results show, gamification predominantly inserts itself in the design through a variety of modalities giving rise to a certain level of complexity as it activates different persuasive strategies and calls on diverse elements. The addition of those enables the creation of a particular incentive that aim to alter a behaviour in a specific manner. The distribution of gamification strategies in HBCSS reveals that (on 16 selected papers) the *goal setting* strategy is the most employed (12 out of 16) followed by *compare progress* (9 out of 16) and *providing feedback on performance* (9 out of 16). This concretely means that the most preferred gamification approach is to commit users to achieve a goal, which is often coupled with an monitoring of these goals with others (Cugelman, 2013). The implementation is mostly done by *feedback* (9 out of 16), *leaderboards* (8 out of 16), and *points* (7 out of 16) which is obviously in line with the previous mentioned strategies. Hence, gamified HBCSS for healthier lifestyles commonly construct on three prevailing aspects: a definition of target(s), a feedback loop and a social component.

As a matter of principle, all of these gamified HBCSS aim to create a long-term engagement. In order to have a better picture of which gamification strategies (and elements) effectively foster long-term use, we need to appreciate how these studies report it. However, an overwhelming majority of the papers use cross-sectional study designs (14 out of 16) to gather data on gamified HBCSS. According to our procedure presented above, it already underlines a serious lack of consideration regarding long-term perspective and lasting effects of gamification. The consequences of such results are further commented in the next section *(See Section 6).*

Publication	*Use context*	*User context (sample size)*	*Technology context*	*Gamification strategy*	*Gamification element*	*Study design (duration of intervention)*
(Buchem et al., 2015)	Rising physical activity	Senior users (n=10)	Wearable device, Computer software	Goal setting, Social connectivity, Capacity to overcome challenges	Badges, Progress, Challenge	Cross-sectional (4 weeks)
(Chen and Pu, 2014)	Rising physical activity	Students and lab workers (n= 36)	Wearable device, Mobile application	Compare progress, Social connectivity, Capacity to overcome challenges	Points, Badges, Leaderboards	Cross-sectional (2 weeks)
(Coombes and Jones, 2016)	Rising physical activity	Children age 8–10 (n=80)	Wearable device	Goal setting, Providing feedback, Compare progress	Points, Feedback, Challenge	Intervention (9 weeks) + follow up (20 weeks after)
(El-Hilly et al., 2016)	Smoking cessation	Smokers (n=16)	Mobile application	Goal setting, Capacity to overcome challenges, Reinforcement	Achievements, Levels	Cross-sectional (5 weeks)
(Giannakis et al., 2013)	Rising physical activity	Young adults (n=5)	Mobile device, Mobile application	Providing feedback	Feedback	Cross-sectional (4 weeks)
(Ilhan et al., 2016)	Enhancing sleeping habits	Recruited participants (n=26)	Mobile application	Goal setting, Capacity to overcome challenges, Providing feedback, Reinforcement, Compare progress	Points, Feedback, Leaderboards, Story/Theme	Cross-sectional (2 weeks)
(Jones et al., 2014)	Enhancing eating habits	Elementary school students (n=251)	Ambient display	Goal setting, Reinforcement, Capacity to overcome challenges, Fun and playfulness	Rewards, Levels, Story/Theme	Cross-sectional (2 weeks)
(Kadomura et al., 2014)	Enhancing eating habits	Children (n=5)	Mobile device, Mobile application	Providing feedback, Fun and playfulness	Feedback, Theme	Cross-sectional (9 days)

Publication	*Use context*	*User context (sample size)*	*Technology context*	*Gamification strategy*	*Gamification element*	*Study design (duration of intervention)*
(Katule et al., 2016)	Monitoring nutrition and physical activity	Households (n=14)	Mobile application	Goal setting, Capacity to overcome challenge, Reinforcement, Compare progress, Social connectivity	Points, Badges, Theme, Leaderboards, Challenge	Cross-sectional (6 weeks)
(Kim et al., 2017)	Stretching exercises	Students (n=42)	Wearable device	Goal setting, Providing feedback, Reinforcement	Rewards, Feedback, Clear goals	Cross-sectional (5 days)
(Ogi et al., 2015)	Improving health consciousness	Students (n=41)	Mobile device, Mobile application and Digital signage	Goal setting, Providing feedback, Reinforcement, Compare progress, Social connectivity	Levels, Feedback, Leaderboards,	Cross-sectional (14 weeks)
(Shameli et al., 2017)	Rising physical activity	Users of the selected application (n=800000)	Mobile application	Goal setting, Compare progress	Challenge, Leaderboards	Cross-sectional (1 week)
(Thorsteinsen et al., 2014)	Rising physical activity	Recruited participants (n=21)	Website, SMS	Providing feedback, Reinforcement, Compare progress	Points, Feedback, Leaderboards	Cross-sectional (12 weeks)
(Wortley, 2015)	Rising physical activity	Case study	Wearable device, Mobile application	Goal setting Providing feedback, Reinforcement	Feedback	Case study (2 years)
(Zhao et al., 2016)	Rising physical activity	Recruited participants (n=36)	Wearable device, Mobile application	Goal setting, Capacity to overcome challenge, Reinforcement, Compare progress, Social connectivity	Points, Levels, Leaderboards, Theme, Challenge	Cross-sectional (70 days)
(Zuckerman and Gal-Oz, 2014)	Rising physical activity	Recruited participants (n=40)	Mobile application	Goal setting, Providing feedback, Compare Progress	Points, Feedback, Leaderboards	Cross-sectional (2 weeks)

Table 2. Selected studies for review

6 Discussion

The main objective of this paper was to study how extant research treated the link between long-term use and engagement in gamified, IT-reliant systems. We argue that gamification for digital health promotion should be apprehended as a process which effects have to be analysed on the long term. The research designs found in our selected studies already suggest that there is room for improvement regarding the significance of the reported outcomes, notably in terms of health behaviour change. Nevertheless, the manner these papers consider long-term engagement (if at all) is still particularly informative about the current state of discussions on this matter. To that end, and as stated above, we realize a categorization of the retained papers, following the extent they really discuss long-term usage.

Four papers do not devote any part of their work to develop a long-term perspective. Interestingly, among these, the gamified intervention for digital health behaviour change is rather short-timed: 5 days (Kim et al., 2017), 9 days (Kadomura et al., 2014), 14 days (Chen et al., 2014) or 4 weeks (Giannakis et al., 2013). The mechanisms employed in these papers can be classified as short-term actions, which aim at responding to small-timescale behavioural trends (Carrino et al., 2014). We cannot subsequently take them into account for further analysis, as we cannot fully ascertain if the described design really induces a sustainable behaviour change in the long run or not. A second group of studies only mentions this issue in the limits of their work or as a future research. Buchem et al. (2015) call for a longitudinal study in order to confirm the positive impact that has been measured. In the same vein, El-Hilly et al. (2016) express that it is required to evaluate the effectiveness of their proposed framework by assessing their relation to long-term effects of gamification. The third group is composed of papers that identify this issue, include it in their reflection, but do not provide enough follow-up data to prove the viability of the effects on behaviour change (produced by their gamified system). We also included the narrative case study made by Wortley (2015) in this group, given that the data (observations and measures) do not come from different (at least two) moments in time. However, all these studies can contribute with a first insight about how to consider and evaluate continuous use. Here are our main observations.

The post use questionnaire/post intervention survey. This represents a medium to appreciate if gamification has provided beneficial effects. However, in the cases of Ilhan et al. (2015) and Ogi et al. (2015), there is no indication about the modalities in terms of *follow-up*, except that users fulfilled the survey at the completion of the intervention. In consequence, we cannot affirm with certitude that the reported effects are sustainable on the long run, especially as the duration of the involvements (respectively two weeks and one month) are probably not sufficient to undoubtedly generate a behaviour change. For the record, both observe rather positive outcomes in relation to health behaviour change: Ilhan et al. indicate that 65 % of the recruited participants state that a gamified app would change sleep-wake behaviours in the long term. Ogi et al. (2015) question if the gamified systems have improved users' health consciousness: 57% moderately agree and 26% agree.

The novelty effect. Another interesting point is brought by Katule et al. (2016) and Thorsteinsen et al. (2014): effects of novelty carried by gamification. The introduction of a technology often leads to a high usage in the beginning of the intervention, due to the interest in the new implemented technology. In that respect, a significant use might not correspond to an achievement, but might be driven by curiosity and attractiveness. In consequence, it can fade along the user getting accustomed and familiar with service/device. Both studies suggest that gamification is a viable tool (in a short term) that need further investigation to observe if the effects are sustainable.

At the end of the day, gamification interventions lower the interest. Implementation of game design elements can lead to a potential negative impact, given that some selected gamification elements might, as the time passes, reduce the implication and interest in using the digital service or device (Jones et al., 2014; Zuckerman and Gal-Oz, 2014). Gamification, in that respect, might annoy users and lose all value and potency on the long run. Comparatively, such research has been undertaken about primarily utilitarian smartphone applications with hedonic or game design features (Mettler et al., 2014). The results show that gamification did not allow for a stabilized long-term usage scenario and negatively impacted the usage duration of the apps.

Intrinsic and extrinsic motivation. Well-established and a common matter in incentive theories, intrinsic and extrinsic motivation play a key role regarding continuous use of gamified systems. Intrinsic

motivation corresponds to a self-determined motivation (e.g. interest, enjoyment) while extrinsic motivation relates to an external factor that drives the motivation (Ryan and Deci, 2000). This may, for instance, be an external element (e.g. rewards or punishment) but also an internal motivation conditioned by an external factor such as congruence, social norms or external obligations. Wortley (2015) denotes that gamification potentially engenders an increase of intrinsic motivation (e.g. pleasure) and is more likely to provide sustainable outcomes. He develops the idea that the effects of intrinsic motivators mediate the effect of extrinsic motivators. As a consequence, intrinsic motivators are the principle vectors that contribute to the adoption of a healthier lifestyle.

Gradual addition of features. Zhao et al. (2016) express that applying a gradual addition of features/means (or substitute them on occasion) helps to sustain participants' interest and use. Thus, (consistent) updates of gamified systems might increase, to a certain extent, usage of the digital service or device. However, Zhao et al. (2016) precise that these findings only relate to data taken during their intervention and that there is a requisite for future analysis.

At last, one single paper (Coombes and Jones, 2016) has done a follow-up research regarding gamification for HBCSS. The data has been gathered through a (+20 weeks) post-intervention measurement (using a wearable device) and a self-reported record (via a diary). Physical activity overall did not appear to be significantly higher at the follow-up between intervention participants and controls. There is consequently no evidence of a large intervention impact by the gamified system, even if the self-reported physical activity has been increased since the end of the intervention. Thus, the only study that meets our highest criteria, reports no significant effects of gamification for digital health behaviour change in the long term.

To conclude, the few identified studies show that there is a lack of evidence concerning continuous engagement and/or long-term effects of gamification interventions applied to HBCSS toward healthier lifestyles. This generates another implication: we cannot reasonably determine and label some gamification strategies/elements as more effective than others on the long run. At this point, gamification for healthier lifestyles is simply not proven to be effective in a long-term perspective. Considering which gamification approach is more suitable consequently becomes a pointless quest. As shown above, research suggests that gamification might induce behaviour change toward healthier lifestyles. Even if the long-term is insufficiently addressed (and that we do not possess enough evidence); it does not mean that gamification in HBCSS is ineffective on the long run. Maintaining long-term user commitment through gamification is surely a challenge (El-Hilly et al., 2016). Likewise, altering a lifestyle habit is proven to be difficult, notably in relation to health. This is precisely why gamification for HBCSS needs further longitudinal (or prospective observational study) research, in order to better comprehend the long-term perspective, and offer solutions that can tackle these challenges.

Engaging in longitudinal studies can be demanding as well: it requires time to develop an effective research design. We do not intend to enter into any judgements of intentions, we pertinently understand how difficult it is to undertake research in an environment that pressures for constant publication. Not to mention that a longitudinal approach may rise financial demands and request a higher involvement from the study participants (Caruana et al., 2015). Still, there is potential to overcome these hurdles. For instance, further longitudinal studies might build on secondary data and take advantage of existing data sets (Doolan et al., 2017). Likewise, existing cross-sectional studies can be employed as preliminary assessments, already providing a theoretical/practical groundwork upon which a new prospective observational study may develop (Caruana et al., 2015). Even planning a single follow-up after the main intervention is valuable in the context of HBCSS: it provides an early consideration of the degree of behaviour change over time and informs about how technology systems are integrated in situ (Anders et al., 2012; Caruana et al., 2015).

6.1 Implications

From a theoretical viewpoint, our study adds a first understanding of the long-term engagement to the existing research in gamification for digital health behaviour change. We address this particular issue, which is too often neglected, and propose an approach to measure and evidence long-term engagement in gamified HBCSS toward healthier lifestyles. Our work especially demonstrates that there is a clear gap regarding proved continuous perspective in these systems, which seriously challenges the

effectiveness of gamification for digital health behaviour change. At this point, the longstanding effects induced in terms of health behaviour change are fairly speculative, which goes against the fundamental purpose of these services: to constantly change a behaviour towards a healthier lifestyle. Additionally, we compile and discuss all the indications found in our selected literature about long-term engagement, in order to summarize and evaluate what is already known.

From a methodological perspective, we call for the application of longitudinal and prospective observational studies or follow-ups after the initial or main intervention. Only through these procedures, we will be able to better understand the effects of gamification for digital health behaviour change. We also believe that users need to feel a constructive and positive game-based experience that is linked to the underlying non-game setting (Nicholson, 2012). In fact, as we stated above, gamification should be a matter of specific association between strategies and elements regarding a particular context. In order that gamification in HBCSS become meaningful on the long run, practitioners, scholars and designers ought to consider the novelty effects that gamification may drive (and how to overcome it). Alongside they should be aware of the loss of interest and the annoyance that (too much) gamification potentially entails as time passes. An answer to this hurdle might be the gradual addition of features or, in the same manner, a change of means to sustain users' interest and engagement. Finally, leaning toward users' internal satisfaction and enjoyment regarding the gamified systems is critical. Users creating and controlling their own goals are more likely to find internal meaningful connections to the underlying activity and thus continue performing it over time (Zuckerman and Gal-Oz, 2014).

6.2 Limitations and future work

Our effort to select an appropriate sample that allows comparison drastically reduces the sample size for analysis. As we have seen, gamification for HBCSS can be employed in several contexts. We decided to target gamified interventions on individual lifestyle habits in order to avoid, for instance, the presence and the interference of a contextual condition (e.g. diabetes). We assume that the continuous engagement in gamified HBCSS for rehabilitation or disease management relies on distinct mechanisms and motivations which primarily relate to the given condition. That restriction, however, provides the opportunity for further research studies. An investigation on disease management could complete the research on the long-term perspective in gamified HBCSS and potentially highlight a better representation of this concern.

Considering that we aimed to conduct a first scoping review on the long-term engagement in the literature of gamification for digital health behaviour change, we made the decision to completely rely on our selected studies to define concepts like *long-term engagement* or *continuous use*. Given that we did not find much evidence or empirical material to do so, the presented notions may have remained relatively vague. As a consequence, there might be the need for a better conceptualization. A potential approach to tackle this issue might be to consider how long-term engagement of gamified systems has been investigated in other fields. It could certainly constitute a valuable input to better understand all the challenges that the long-term engagement represents.

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