

# Gamification in Health Behavior Change Support Systems - A Synthesis of Unintended Side Effects

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**Abstract.** Gamification has become a popular and promising tool to positively impact the usage of health behavior change support systems (HBCSSs). Fun and engaging components are purposefully integrated in the design of HBCSSs in an effort to encourage users to employ the system in a more regular manner or over a longer period of time. Although extant research has made extensive efforts to understand the psychological and behavioral outcomes of gamification, its potential unintended side effects have been mostly neglected. We approached this gap by reviewing 33 articles on gamification in HBCSSs. We identified 16 potential unintended side effects in five categories. By taking a critical view, our research contributes to a more nuanced approach to gamification, which helps to understand how it can be utilized as a valuable tool for developers that motivates and does not harm users of HBCSSs.

**Keywords:** Gamification, Health Behavior Change, Literature Review, Side Effects, Negative Effects

## 1 Introduction

In today's Western societies the main health challenges and most important risks for mortality have been shifted from pre-modern health risks such as malnutrition and poor water quality to health risks that are generated by the modern world itself, like high blood pressure, tobacco use, high blood glucose levels, obesity, and high cholesterol levels [1]. Thus, major public health concerns are often directly linked to people's individual health behavior and modern lifestyle habits such as sedentary living, chronic stress, and intake of energy-dense foods [1]. Trying to tackle the challenge of unhealthy modern lifestyles, health behavior change support systems (HBCSSs) are a promising approach to positively influence people's health behavior [2-4]. Typical examples of such HBCSSs include systems that aim to foster healthy eating habits [5, 6], systems that motivate their users to be more physically active [7, 8], or systems that help to properly manage chronic diseases [9, 10]. HBCSSs come in many forms, such as wearables, mobile apps or dedicated software. However, recent research suggests that

people often do not use HBCSS frequently and over a sustained period of time [11]. As a consequence, the desired beneficial health behavior may not be maintained. Trying to address this issue, developers of HBCSS frequently employ gamification. Gamification refers to the implementation of game elements in non-game contexts [12].

In HBCSSs gamification is primarily applied to make the usage of a HBCSS more engaging and fun, thus encouraging users to use the HBCSS more regularly or promoting the completion of certain health-related activities [2, 4]. However, designing meaningful and effective gamification is associated with high complexity and extensive resource requirements [13]. In fact, researchers have repeatedly criticized practitioners and fellow researchers for oversimplifying gamification by superficially implementing single game elements such as points or badges [14]. Adding to that, recent research suggests that gamification approaches that do not consider the overall application context and gamification concept are less effective than more holistic approaches to gamification [15]. Mindless approaches to gamification might not only lack effectiveness in increasing users' motivation and engagement but additionally cause unintended side effects that could counteract the positive effects of gamified systems or even harm their users [16, 17]. Especially in a context like HBCSSs, where systems are intended to have a positive impact on peoples' health behavior, unintended side effects of gamification can have serious negative influences on users' health outcomes (e.g., by unintentionally incentivizing wrong exercising). Thus, developers of gamified HBCSSs need to be aware of potential unintended side effects in order to incorporate suitable strategies to address them into the design process. Within this research, we hence aim to answer the following research question:

*RQ: What unintended side effects may occur when implementing gamification in HBCSSs?*

Past research on gamification has focused on investigating the positive effects of gamification on psychological and behavioral outcomes [18, 19] or proposing theoretically grounded frameworks for designing specific gamified systems [e.g., 20]. Risks and negative aspects of gamification were only treated as side notes [e.g., 1, 21]. Some researchers have started to investigate negative aspects of gamification in general [16] or within educational systems [17]. However, those studies are based on the analysis of secondary literature and do not consider the special context of HBCSSs. This is rather problematic since (1) unintended side effects of (gamified) HBCSSs yield potential to seriously harm users' health and thus substantially differ from side effects in less serious contexts and (2) the investigated secondary literature did not thoroughly elaborate on negative aspects of gamification. In consequence, research still lacks a comprehensive overview of unintended side effects of gamification in HBCSSs. Although existing studies make first valuable contributions to the research field, a synthesis of literature is necessary to understand unintended side effects of gamification in particular with regard to specifics of HBCSSs and the serious contexts of HBCSSs.

To answer our research question, we conduct a structured review of literature to identify and analyze relevant academic publications. In particular, we review those publications that discuss and elaborate on potential unintended side effects of applying

gamification to HBCSSs. An overview and explanation of unintended side effects of gamification in HBCSSs helps to (1) guide developers of gamified HBCSSs in identifying potential risks within their gamification concepts and (2) raise awareness that gamification is not a silver bullet which creates positive outcomes all by itself and without extensive design considerations.

This paper proceeds as follows. The next section provides an outline of gamification in HBCSSs as well as an overview of research on unintended side effects of gamification. Section three describes our research approach, while section four presents our results. We discuss our results in section five and briefly conclude our paper in section six.

## **2 Background**

### **2.1 Gamification in Health Behavior Change Support Systems**

Literature provides two prevailing definitions for gamification. Huotari and Hamari [22] refer to gamification as the process of enhancing services with motivational affordances for gameful experiences. Hamari et al. [19] advanced this conceptualization by introducing the three essential concepts in gamification research (i.e., implemented motivational affordances, resulting psychological outcomes, and further behavioral outcomes). Deterding et al., define gamification as “the use of game design elements in non-game contexts” [12]. Popular game elements used in gamification include points, badges, leaderboards, and time constraints [12]. In general, gamification aims to utilize peoples’ growing passion for games to positively influence their personal motivation or perception concerning a selected action in order to make it more engaging and fun [2, 21, 23]. However, it is important to differentiate gamification and serious games. Gamified systems are no full-fledged games. In fact, game elements in gamified systems are only means to foster certain behaviors and not the main object of the system [24]. Serious games, on the other hand, are fully-developed games that serve specific non-entertainment purposes [24].

Extant research has made extensive efforts to investigate psychological and behavioral effects of gamification in various research fields such as education [25, 26], crowdsourcing [27], or enterprise systems [21]. Among these research fields, HBCSSs have emerged as one of the most relevant application areas for gamification [1, 28]. In HBCSSs, gamification is primarily applied for motivating individuals to continue using the systems more regularly or promoting the completion of activities or tasks that are associated with positive health outcomes [2, 4]. According to extant literature, there are three major groups of use contexts for gamification in HBCSSs [2]: (1) Individual lifestyle habits (e.g., fitness, food consumption, unhealthy habits), (2) chronic disease management (e.g., diabetes, cancer), and (3) support of health professionals (e.g., for educational purposes or daily habits). However, as we focus our research on unintended side effects concerning patients and users aiming to improve their health status as well as the fact that a majority of HBCSSs in group three can also be classified as educational systems, we concentrate our analysis on such HBCSSs belonging to group one and two.

## 2.2 Unintended Side Effects of Gamification

Extant research on gamification has primarily focused on investigating intended psychological and behavioral effects on gamification. Two studies exist that focus on shedding light on potential unintended side effects of gamification. Hyrinsalmi and Kimppa [16] conducted a meta study and reviewed existing literature reviews on gamification concerning negative impacts. They classify their results in two main groups: (1) Limiting issues and (2) harmful issues. However, they also state that most reviewed studies had only little if any discussion on the negative effects of gamification. As a result, their data basis is scarce and lacks an in-depth discussion of side effects and potential consequences. Second, Toda et al. [17] reviewed literature on gamification in education and identified four negative effects (i.e., indifference, loss of performance, undesired behavior, and declining effects). However, the results of their study are only applicable to the context of educational systems. In addition to these two studies, some research has dealt with risks or negative effects of gamification as a side note. For example, Thiebes et al. [21] have discussed four risks of gamification in information systems, and Johnson et al. [1] outline some negative aspects of gamification found in studies in health and well-being. Furthermore, Kim and Werbach [29] elaborate on ethical issues in applying gamifications such as potential for manipulation and exploitation. In summary, to the best of our knowledge, no study exists that focuses on identifying and purposefully reasoning on unintended side effects of gamification in HBCSSs.

## 3 Structured Literature Review

### 3.1 Data Collection

For the identification of publications discussing potential unintended side effects of gamification in a HBCSSs context, we applied a systematic online literature database search following the guidelines by Levy and Ellis [30]. We thus searched the scientific databases IEEE Xplore, ProQuest, AIS Electronic Library, ACM Digital Library, EBSCO Host, and ScienceDirect using the following search string: *TITLE-ABSTR-KEY (gamif\*) and TITLE-ABSTR-KEY(health\* OR medic\* OR life\* OR fitness OR well-being) and TITLE-ABSTR-KEY(risk\* OR danger\* OR peril\* OR effect\* OR negative\* OR disadvantage\*)*.

Where possible, our search was limited to peer-reviewed publications published in 2010 or later, since gamification only gained widespread recognition by researchers and practitioners in 2010. The database search yielded a total of 212 publications, excluding duplicates. Two researchers separately assessed the relevance of each article by utilizing predefined exclude criteria. In this process, we excluded ten articles not written in English, seven articles that were not peer-reviewed, 140 articles that had no focus on gamification in HBCSSs (i.e., they dealt with related concepts such as serious games or researched gamification in a non-healthcare context), and 43 articles that did not discuss any unintended side effect of gamification. In addition, a forward and backward search was conducted on the twelve relevant articles which lead to the

identification of three additional relevant publications and a set of 15 relevant articles. In a second step and in an effort to integrate scientific literature from health and medical perspectives, we searched the scientific database PubMed using our research string. Our PubMed search yielded a total of 145 additional unique publications. By screening these publications against our exclusion criteria, we excluded 104 publications that had no focus on gamification in HBCSSs and 23 publications that did not discuss any unintended side effects of gamification. Through searching PubMed, we identified 18 additional relevant publications, which led to a final set of 33 relevant publications.

### 3.2 Concept-centric Data Analysis

To identify unintended side effects of gamification in health & well-being, we conducted a manual content analysis. Two researchers independently coded the 33 articles with regard to unintended side effects using an open coding approach [31]. As suggested by Strauss and Corbin [31], during open coding, the data was broken down into discrete parts (i.e., text passages), closely examined, compared for similarities and differences, and coded with regard to the phenomena as reflected in the data. The results were iteratively reviewed and discussed with a third researcher to consolidate them. To improve the explanatory power of our results and to find semantically coherent groups, the identified side effects were grouped into categories if they were logically related to the same subject.

## 4 Results

Our review of relevant literature yielded a total of 16 potential unintended side effects due to the application of gamification in HBCSSs, which we grouped into five categories of unintended side effects. Table 1 provides an overview of the categories of unintended side effects. It also highlights for which unintended side effects we were able to find empirical support within the reviewed literature and which side effects are specific to the HBCSSs context. We describe each unintended side effect in detail below.

### 4.1 Adverse Motivational Outcomes

**Undermining Intrinsic Motivation.** Researchers often argue that gamification aims to foster users' intrinsic motivation in order to make using gamified systems more engaging and fun [32]. However, gamified HBCSSs sometimes tend to focus on extrinsic motivation and thereby even corrupt and undermine intrinsic motivation for positive health behavior change [33, 34]. As a result, users' health behavior may become dependent on the presence of the gamified HBCSSs and their motivation may immediately decrease once the extrinsic rewards are not available anymore [1, 33]. Attig and Franke [33], for example, showed in their study that motivation for physical activity can become dependent on the presence of an activity tracker as well as the related game elements and decreases in case the tracker is not available.

**Table 1.** Overview of unintended side effects.

<i>Class of Unintended Side Effects</i>	<i>Unintended Side Effect</i>	<i>Sources</i>	<i>Empirical support</i>	<i>HBCSS specific</i>
<b>Adverse Motivational Outcomes</b>	Undermining Intrinsic Motivation	[13, 33-42]	[33-35, 38, 40, 41]	No
	Motivation Decreasing Over Time	[15, 35, 38, 40, 43-48]	[35, 40, 43, 45-48]	No
	Unfulfilled Expectations	[36, 45, 49, 50]	[45, 49]	No
<b>Informational Noise</b>	Distraction from Health Purpose	[13, 15, 34, 41, 45, 51, 52]	[15, 45, 51, 52]	Yes
	Trivializing the Health Context	[1, 13, 15, 24, 36, 41, 53]	-	Yes
	Reduced Usability	[13, 15, 45, 54]	[45]	No
<b>Reduced Integrity of Exercise</b>	Cheating the Self	[37, 55]	-	Yes
	Rewarding Incorrect Execution	[34, 36, 56]	-	Yes
	Overuse	[13, 55, 57, 58]	[57]	Yes
<b>Demoralization of Users</b>	Cheating Others	[13, 37, 55, 59]	-	No
	Overemphasized Peer Pressure	[37, 38, 41, 57, 60]	[38, 41, 57, 60]	No
	Exaggerated Punishment	[37, 40]	-	No
	Feeling of Manipulation	[36, 42, 49, 57]	[49, 57]	No
	Discouragement Due to Failure	[36, 61]	-	No
<b>Overstepping Boundaries</b>	Privacy Infringements	[13, 36, 37, 40, 44, 55, 60]	[40, 60]	Yes
	Fostering Behavior that Harms Third Parties	[58]	[58]	No

**Motivation Decreasing Over Time.** An often-discussed problem with gamification is novelty effects. Novelty effects describe a situation in which users are often curious and enthusiastic for gamification at first, as it is visually appealing and something they did not experience before [15]. However, interest and enthusiasm for gamification most likely decrease in the long run when these novelty effects wear off. With it, motivation to perform healthy behaviors could decrease as well, ultimately dropping below the initial level of motivation. El-Hilly et al. [40], for instance, describe this effect in their study of a gamified HBCSS for smoking cessation where participants exhibited monotony and decreased levels of engagement as they perceived achievements as repetitive.

**Unfulfilled Expectations.** Gamification of HBCSSs might raise high expectations by claiming to bring fun and engagement to health activities while maintaining therapeutic effectiveness of the system. If these expectations are not met, users might be disappointed, which could lead to decreasing levels of satisfaction. To this end, Lumsden et al. [49] report that participants of their study of different web-based cognitive testing systems were disappointed of a task that had the graphical impression of a game but did not offer any actual gameplay.

## 4.2 Informational Noise

**Distraction from Health Purpose.** Sardi et al. [15] point out that gamification concepts sometimes tend to not provide “a tangible health-driven meaning in terms of the user’s competence and health skills” and that game mechanics are “sometimes wrongly located on the application’s display”. As a result, it can be difficult for users to identify a link between the gamification concept and their health behavior and they do not understand the purpose of certain game mechanics. This effect can lead to a distraction from the core health behavior elements of the system and thus reduce the overall system’s efficacy [34]. For example, Boendermaker et al. [45] conclude in their study that their gamified HBCSSs for attentional bias modification in the context of alcohol consumption contained distracting game elements that negatively influenced the systems efficacy.

**Trivializing the Health Context.** Developers of gamification concepts frequently aim to design visual appearances that resemble existing games [21]. Thus, gamification design is often colorful and eye-catching [1]. In some cases, exaggerated visual design might lead to perceptions that important health topics, which deserve a serious and professional tone, might be trivialized and that gamification is more of a marketing gimmick than a serious tool that supports health behavior change [36]. As a result, recent studies reported that some health professionals shy away from participating in designing gamified HBCSSs as they worry about their credibility and respect among patients [15].

**Reduced Usability.** Introducing gamification to a HBCSS is always associated with adding new possibilities of system interaction for the user. As a result, established paths of human-system interaction may change and users’ might initially be confused as the system does not longer work the way it used to. Gamifying HBCSSs adds an additional layer of interaction complexity and, thus, might lead to an initial decrease in usability [15]. For example, Boendermaker et al. [45] observed that participants in a gamified intervention differed with regard to speed and accuracy of responses in comparison to a non-gamified intervention. They ascribe this observation to the more complex nature of the gamified intervention.

### 4.3 Reduced Integrity of Exercise

**Cheating the Self.** Gamifying HBCSSs can open the door to cheating and exploiting. Especially users that have higher interest in achieving game rewards than the actual health behavior change sometimes try to achieve a target in a way in which it was not supposed to be achieved according to the game rules [13, 37]. Users cheat by, for example, “exploiting inherent sensor-related limitations to fabricate false detection” [37]. Cheating is also promoted by the fact that most gamified HBCSSs are used while being online and without supervision by professionals, which might lower the threshold for lying [55]. Cheating the self can lead to misdirected incentives and false health behavior and might thus negatively impact health-related outcomes [55].

**Rewarding Incorrect Execution.** Creating gamified HBCSSs requires a great variety of different resources and expertise [34]. In particular, developers need to ensure that games’ rewards and progresses adequately reflect people’s health behavior. If the gamification concept is not sufficiently aligned with the desired health behavior change, users might unintentionally be incentivized for wrong or even unhealthy behavior (e.g., distributing a reward although an exercise was not performed correctly) [36].

**Overuse.** Gamification frequently aims to motivate people to use an HBCSS in a more regular manner. However, gamification concepts that are not sufficiently balanced but instead reward exaggerated repetitions of certain tasks might incentivize users to use an HBCSS too excessively and thus overreaching their personal limits [55, 58]. In an extreme case, gamification concepts might lead to users that are “driven by obsession rather than enjoyment [...] resulting in problems relating to overtraining, overexertion and risk taking” [57]. Barrat [57], for example, reported in his study about a gamified HBCSS for cycling that some participants – driven by peer pressure and competition – ended up cycling excessively thereby negatively influencing their overall health and social outcomes.

### 4.4 Demoralizing Effects

**Cheating Others.** As stated before, cheating can be an important problem in gamified HBCSSs. When users cheat they often aim to gain an advantage over other users by exploiting certain game mechanisms in a way that should not be allowed according to the game rules [37]. Cheating can ruin the fairness of competitive game mechanisms and might even result in other users giving up [37]. As a result, dissatisfaction among users that do not cheat might increase [13]. Recent research suggests that users are more likely to cheat the more they are exposed to other users cheating [62].

**Overemphasized Peer Pressure.** Gamification often contains competitive game elements that, for example, enable comparing the scores of different users [37]. However, competition and social comparison is not for everyone. Recent research suggests that introverted users are likely to be demotivated by gamification that contains social comparison [60]. In addition, competitive game elements that publicly

compare the scores of different users can also be discouraging to those who have low scores due to temporary setbacks or simply being new to the system [37]. Thus, studies found that social comparison can have negative effects on users' health behavior [38]. For example, Horse-Fraile et al. [41] report of collaborative health app studies in which parents complained about the possibility that their children may become demotivated if other families ranked better than theirs did.

**Exaggerated Punishment.** Users might also be discouraged due to the feeling of disproportionate punishment. Even regularly active users might get sick or be otherwise unable to perform desired health-related behavior (e.g., exercises), resulting in a sharp drop of their (average) score [37]. Although this drop might sufficiently represent reality, users' might perceive it as unreasonable and unrepresentative of their health behavior and thus get discouraged or even stop using the HBCSS [37].

**Feeling of Manipulation.** Gamification aims to foster users' motivation to perform certain activities in a specific way or in a more regular manner, for example, by applying rule-based systems. This could cause users to perceive a feeling of being manipulated or forced into performing those actions, especially if the underlying health activity is inherently unstructured and requires a great degree of autonomy. For example, Barratt [57] reports that participants in a study of a cycling application complained about negative experiences due to a restricted level of autonomy.

**Discouragement Due to Failure.** Gamification often relies on goal-oriented game elements. These may discourage users if they fail to meet certain goals despite putting in a lot of effort. According to extant literature, it is particularly important for more serious contexts such as heart diseases [61] that developers avoid a sense of defeat while adjusting the level of difficulty according to users' capabilities.

#### 4.5 Overstepping Boundaries

**Privacy Infringements.** Information about users' health status and health behavior is often sensitive and subject to specific laws which limit the disclosure of healthcare information without explicit consent from the user [36]. Implementing gamification in HBCSSs can add another level of complexity concerning privacy and data protection [13]. Based on game elements additional health information about HBCSS users might be gathered and stored. For example, users' badge collections might disclose information about health status and past health-related behaviors. This can be particularly problematic when unknown third parties, such as employers or insurance companies, start reviewing badge collections by individuals or user groups for specific purposes [36]. Research also indicates that some users are more likely to participate in HBCSSs if they are not required to disclose personal data [60].

**Fostering Behavior that Harms Third Parties.** Gamification of HBCSSs might also cause unintended side effects for third parties outside of the system. This was particularly observed in GPS-based HBCSSs that aim to foster physical activity and

use auto-generated outdoor locations for specific rewards. For example, in 2011 an object used in a GPS-based gamified HBCSS was placed in the Downtown Disney Park in Anaheim, CA, USA. As a result, people that not played the game were scared and triggered a bomb alarm. This led to temporary closure of the park [58]. Another example for behavior that harms third parties might be overcrowding of specific real-world places that promise special rewards as observed in the beginning of Pokémon GO.

## 5 Discussion

Our objective within this research was the identification and analysis of unintended side effects of gamification in HBCSSs. Building on the results described in section four, we were generally able to provide answers to our research question and thus contributed to the knowledge base on gamification. We discuss some of the most interesting findings and their implications in the following.

By intensively reviewing and discussing the 16 identified side effects, we were able to build five logically coherent groups of unintended side effects. First, adverse motivational outcomes describe those side effects which basically result in the main objective of gamification (i.e., fostering user motivation and engagement) not being achieved. Reasons for the occurrence of side effects of this group are diverse. Many researchers emphasize that applying gamification is a demanding process that requires excessive resources and expertise in order to be effective [13, 15]. When developers decide not to include game design knowledge in the design process and instead go for “cheap” gamification solutions that are based on extrinsic rewards that are easy to implement and promise short-term behavior change, their gamification approach is likely to fail in the long run. If adverse motivational outcomes occur, they are likely to negatively impact users’ adoption of gamified HBCSSs. Second, informational noise describes unintended side effects that are related to a flawed visual representation and interaction concept of the gamified HBCSSs. They are often caused by insufficient consideration of the unique seriousness of the health context and thus choosing inappropriate gamification elements. If those unintended side effects occur, users’ might perceive an HBCSS as being less professional and serious. Third, reduced integrity of exercise describes those unintended side effects that can directly lead to health-related disadvantages for the user. Thus, it is particularly important to prevent these side effects from occurring. They are often caused by not carefully aligning the gamification concept of HBCSSs with their core activities and thus providing users with wrong incentives. Fourth, demoralization of users describes unintended side effects that might cause users to stop using the system because they feel treated unfairly. Fifth, overstepping of boundaries describes those side effects that might lead to legal issues for developers of gamified HBCSSs. In order to prevent legal uncertainties in particular when considering the high sensitivity of health-related data, it is very important for developers to prevent these side effects from occurring.

As mentioned before, some side effects are more specific to HBCSSs than others. For example, although cheating the self might occur in any gamification context, its

potential consequences are particularly critical in HBCSSs as they threaten the correct execution of health behavior and thus yield potential harm to users' health. Another side effect that is strongly linked to HBCSSs is the trivialization of the context. While colorful and eye-catching design themes might be unproblematic for less serious contexts, within HBCSSs users might perceive them as especially inappropriate and unprofessional and subsequently avoid using the system for a serious context such as healthcare.

Our research yields some implications for practice. First, by presenting and discussing our results we show that developers of HBCSSs need to be aware of potential drawbacks of gamification. In addition, developers need a set of suitable prevention strategies to address these potential side effects when designing gamified HBCSSs. However, it was beyond the scope of this work to derive such prevention strategies. Thus, we leave it to future research and to developers of gamified HBCSSs to carefully develop prevention strategies that fit the diverse application scenarios of HBCSSs. Concerning implications for research, existing frameworks for gamification of HBCSSs mostly have been created on the basis of potential positive effects of gamification. With regard to our results we think that existing frameworks should be critically reviewed and evaluated whether they adequately consider unintended side effects of gamification.

Our research contributes to the scientific knowledge base in several aspects. By synthesizing knowledge on unintended side effects of gamification in HBCSSs, we contribute to the conceptual knowledge on gamification in the context of health and well-being. In particular, although we acknowledge the various potential positive aspects of gamification, we contribute to conceptual knowledge by taking on a more critical view of gamification, which has so far been underrepresented in gamification research [16, 29]. This critical view leads to a more nuanced perception of gamification and thus contributes to a better understanding of how to apply gamification as a valuable tool that motivates and does not harm users of HBCSSs.

The limitations of this study are as follows. First, our literature base is limited to 33 articles that discuss potential unintended side effects of gamification in HBCSSs. This shows that the topic received only little attention among researchers so far. Although we carefully performed our keyword-based search, we cannot rule out the possibility that we might have missed relevant articles. Second, there are different kinds of HBCSSs with various levels of context seriousness [2]. Thus, side effects might also differ between these different types of HBCSSs. It would be interesting for future research to delve deeper and compare potential side effects of different types of HBCSSs. Lastly, interpreting literature and text passages always leave some room for interpretation. However, we aimed to address this issue by carefully performing the concept-centric data analysis and developing a common understanding of side effects while synthesizing the literature. Future research might further strengthen the knowledge base by conducting qualitative research and gathering primary data from experts of the field. Future research could also aim to delve deeper in order to understand the underlying reasons for the observed side effects and the circumstances under which they occur.

## 6 Conclusion

Although gamification has received tremendous attention from practitioners and researchers interested in HBCSSs, little attention has been paid to the unintended side effects that potentially come with the implementation of gamification in HBCSSs. Within this research, we have taken a first step towards closing this gap by reviewing past research on gamification in HBCSSs and synthesizing 16 unintended side effects that may occur when using gamification. Our research adds to the knowledge base on gamification by, for the first time, providing a comprehensive overview of potential unintended side effects. We also contribute to a more nuanced view of gamification, which helps relieving gamification from unrealistic expectations threatening to position it as a silver bullet rather than a valuable tool for developers of HBCSSs. Future research should delve deeper into this topic and examine in more detail under which circumstances such side effects can occur and how they can be avoided or counteracted.

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