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How gamification motivates: An experimental study of the effects of specific game design elements on psychological need satisfaction

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ABSTRACT

The main aim of gamification, i.e. the implementation of game design elements in real-world contexts for non-gaming purposes, is to foster human motivation and performance in regard to a given activity. Previous research, although not entirely conclusive, generally supports the hypothesis underlying this aim. However, previous studies have often treated gamification as a generic construct, neglecting the fact that there are many different game design elements which can result in very diverse applications. Based on a self-determination theory framework, we present the results of a randomized controlled study that used an online simulation environment. We deliberately varied different configurations of game design elements, and analysed them in regard to their effect on the fulfilment of basic psychological needs. Our results show that badges, leaderboards, and performance graphs positively affect competence need satisfaction, as well as perceived task meaningfulness, while avatars, meaningful stories, and teammates affect experiences of social relatedness. Perceived decision freedom, however, could not be affected as intended. We interpret these findings as general support for our main hypothesis that gamification is not effective per se, but that specific game design elements have specific psychological effects. Consequences for further research, in particular the importance of treatment checks, are discussed.

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1. The promise of motivation through gamification

Video games have become increasingly popular among all age groups and genders in recent years (Entertainment Software Association, 2015), and are often considered one of the central entertainment media of the future (cf. McGonigal, 2011). Without a doubt, video games inherently possess a high level of motivational potential (cf. Garris, Ahlers, & Driskell, 2002; Gee, 2007; Hense & Mandl, 2014; Przybylski, Rigby, & Ryan, 2010; Rigby & Ryan, 2011; Ryan, Rigby, & Przybylski, 2006; Yee, 2006). Given this potential, the idea of using the motivational power of video games for real-world applications is not unreasonable (Rigby & Ryan, 2011). This idea is at the root of current discussions concerning the concept of gamification.

Gamification refers to the “use of game design elements within non-game contexts” (Deterding, Dixon, Khaled & Nacke, 2011, p. 1).

The central idea is to take the ‘building blocks’ of games, and to implement these in real-world situations, often with the goal of motivating specific behaviours within the gamified situation. Many authors see gamification as an innovative and promising concept that can be applied within a variety of contexts (Werbach & Hunter, 2012; Zichermann & Cunningham, 2011; Zichermann & Linder, 2013).

The contexts in which gamification has previously been implemented include the following: work (Arai, Sakamoto & Washizaki, 2014; Fernandes et al., 2012), education (Landers & Landers, 2014; Shi, Cristea, Hadzidedic, & Dervishalidovic, 2014), crowdsourcing (Liu, Alexandrova & Nakajima, 2011; Mekler, Brühlmann, Tuch, & Opwis, 2015), data-collection (Downes-Le Guin, Baker, Mechling, & Ruyle, 2012), health (Jones, Madden, & Wengreen, 2014), marketing (Hamari, 2013, 2015), social networks (Farzan & Brusilovsky, 2011), and environmental protection (Gustafsson, Katzeff, & Bang, 2009). Within all these contexts, it is expected that gamification can foster the initiation or continuation of goal-directed behavior, i.e. motivation (Schunk, Pintrich, & Meece, 2010).

Although empirically the majority of studies indicate more positive than negative or null effects of gamification on motivation,

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the evidence base on its effectiveness is still lacking due to limitations of study design and analysis strategies (Hamari, Koivisto & Sarsa, 2014; Seaborn & Fels, 2015). Additionally, there is a lack of theoretical foundation to explain these motivational effects (Seaborn & Fels, 2015); this means that the question *how gamification motivates* has not been addressed sufficiently until now. To answer this question, and consequently advance gamification research, psychological theories of motivation must be applied.

Another problem with the state of current research is that many studies treat gamification as a uniform concept, while in practice, the specific designs and realizations of gamification environments can be quite diverse. Since gamification can take many forms and can combine game design elements in many different ways, it is inappropriate to study the motivational effects of gamification as a generic construct. Instead, the impact of different game design elements within a given context should be the focus of inquiry.

Given the limitations of the previous research outlined above, the first goal of our paper is to apply a self-determination theory framework (Deci & Ryan, 1985; Ryan & Deci, 2002) in the context of gamification, and to explain the motivational power of game design elements according to the theory of psychological need satisfaction (cf. Deci & Ryan, 2000; Ryan & Deci, 2002). The second goal is to investigate different game design elements, using an experimental study, in order to explain the specific effects of these game design elements on psychological need satisfaction.

2. Gamification

The term gamification emerged in the early 2000s (Marczewski, 2013), and has been the focus of increased attention since the beginning of the 2010s (Deterding, Dixon, et al., 2011; Werbach & Hunter, 2012). The central idea behind gamification is to harness the motivational potential of video games by transferring game design elements to non-game environments (Deterding, Khaled, Nacke & Dixon, 2011). However, despite the increasing number of gamified applications, there is still no universally accepted scientific definition of the term (Deterding, Khaled, et al., 2011; Seaborn & Fels, 2015; Werbach & Hunter, 2012).

Described by Groh (2012) as “state of the art”, the most current and widely used definition of gamification is the one already cited above: “the use of game design elements in non-game contexts” (Deterding, Dixon, et al., 2011, p. 1). In order to avoid unnecessarily limiting the goals of gamification, this definition expressly omits possible purposes. Instead, it relies on the four semantic components (1) *game*, (2) *elements*, (3) *design*, and (4) *non-game contexts*.

- (1) The term *game* is defined by Salen and Zimmerman (2004) as “a system in which players engage in an artificial conflict, defined by rules, that results in a quantifiable outcome” (p. 80). While the concept of *game* refers to rule-based forms of play activities, *play* refers to free and explorative activities (Groh, 2012). Accordingly, *gamification* is related to the rule-based, goal-oriented nature of games (Deterding, Dixon, et al., 2011).
- (2) The term *elements* allows us to distinguish gamification from serious games (Deterding, Dixon, et al., 2011). Whereas serious games are fully-developed games serving a specific, non-entertainment purpose (Deterding, Dixon, et al., 2011; Yongwen, Johnson, Moore, Brewer & Takayama, 2013), gamification refers to the use of distinct game building blocks embedded in real-world contexts. Deterding, Dixon, et al. (2011) propose to define game design elements as those elements that are characteristic of games, i.e. that can be found in many games, and that are significant to the

meaning of the game (Deterding, Dixon, et al., 2011; Deterding, Khaled, et al., 2011).

- (3) The term *design* contrasts game design elements with game-based technologies. Whereas the underlying technologies of the game include technological aspects such as game engines or controllers, the definition of gamification refers explicitly to a deliberate design process (Deterding, Dixon, et al., 2011; Deterding, Khaled, et al., 2011).
- (4) Finally, the term *non-game contexts* does not specify the possible areas in which gamification could be applied, and thus leaves the definition open for potential usage scenarios. The only context excluded by definition is the use of game design elements either within the games themselves or in the game design process (Deterding, Dixon, et al., 2011).

To summarize, gamification is defined as “the use of design (rather than game-based technology or other game-related practices) *elements* (rather than fully developed games) *characteristic for games* (rather than play or playfulness) *in non-game contexts* (regardless of specific usage intentions, contexts, or implementation media)” (Deterding, Dixon, et al., 2011, p. 5).

Referring to this understanding of gamification, Werbach (2014) claims that not every use of game design elements in non-game contexts should be labelled gamification. He argues that, following the definition given by Deterding, Dixon, et al. (2011), every single use of a particular game design element would have to be called gamification, e.g. the display of progress bars in computer programs. Since such progress bars are intended solely as a feedback device for the user, and have no gameful or playful intention, they should not be termed gamification. This contrasts, for example, progress bars in LinkedIn, which are intended to evoke game-like user experiences (Werbach, 2014). Thus, Werbach (2014) proposes to define gamification as “the process of making activities more game-like” (p. 6). Within this definition, he focuses on practices that elicit user experiences typical of games. Accordingly, he regards the essence of gamification to be the selection, application, implementation and integration of game design elements, rather than simply the use of these.

However, Werbach's definition lacks several of the specifications discussed above, as it does not refer to any method or element that could be used for creating user experiences characteristic of games. Therefore, it seems reasonable to connect the elemental definition proposed by Deterding, Dixon, et al. (2011) with the process definition proposed by Werbach (2014), and in so doing make use of their distinct advantages. Whereas Deterding, Dixon, et al. (2011) focus on the building blocks of gamification yet disregard the user's experience, Werbach (2014) understands gamification as a process. He focuses on playful activities and on the user experiences they trigger, yet remains vague in regard to how these experiences can be created. Thus, this paper draws on a definition that combines both views. We define gamification as the process of making activities in non-game contexts more game-like by using game design elements.

3. Game design elements

Game design elements are the basic building blocks of gamification applications (Deterding, Dixon, et al., 2011; Werbach & Hunter, 2012). They are largely equivalent with game design patterns (Björk & Holopainen, 2004; Kelle, Klemke, & Specht, 2013). In the context of games and gamification, several authors have proposed compilations of recurring game design elements (cf. Kapp, 2012; Robinson & Bellotti, 2013; Werbach & Hunter, 2012, 2015; Zichermann & Cunningham, 2011; Zichermann & Linder, 2010). Reeves and Read (2009), for example, propose “Ten Ingredients of

Great Games”, which include *representation of oneself through avatars, narrative context, feedback, competition and teams*. Werbach and Hunter (2012) identify 15 important components, among them *avatars, badges, leaderboards, points and teams*. In particular, they highlight the so-called “PBL triad” – the interplay of *points, badges and leaderboards*, which they consider characteristic of gamified applications (Werbach & Hunter, 2012).

Despite several parallels and overlaps between these lists, they are largely different. This difference reveals that the decision as to which building blocks should be identified as characteristic game design elements is often somewhat arbitrary and subjective. In this paper, we do not aim to compile another list of characteristic game design elements. Instead, our goal is to investigate the effects of a selection of specific game design elements, a selection that is not exhaustive, but that represents some of the game design elements most often discussed.

Among these typical game design elements, which we will discuss in more detail below, are (1) *points*, (2) *badges*, (3) *leaderboards*, (4) *performance graphs*, (5) *meaningful stories*, (6) *avatars* and (7) *teammates*. Our focus on this selection of elements is based on their direct visibility to the players, how easily one can activate or deactivate them in an experimental setting, and how strongly they can be expected to address motivational mechanisms within our theoretical framework (cf. next section). Whereas other game design elements such as *competition* or *progress* depend not only on the perceptible design aspects of the application or the game but also on features of its underlying mechanics, the elements we discuss below are part of the game surface, and thus are easily implemented by the game designers. This allows these elements to be manipulated independently of one another, which in turn enables their specific effects to be detected within empirical research (Bedwell, Pavlas, Heyne, Lazzara, & Salas, 2012). Game design elements that are present at a surface level can be manipulated more easily than game design elements that express functions of elements or that trigger user experiences.

- (1) *Points* are basic elements of a multitude of games and gamified applications (Zichermann & Cunningham, 2011). They are typically rewarded for the successful accomplishment of specified activities within the gamified environment (Werbach & Hunter, 2012, 2015), and they serve to numerically represent a player's progress (Werbach & Hunter, 2012, 2015). Various kinds of points can be differentiated between, e.g. experience points, redeemable points, or reputation points, as can the different purposes that points serve (Werbach & Hunter, 2012). One of the most important purposes of points is to provide feedback. Points allow the players' in-game behavior to be measured, and they serve as continuous and immediate feedback and as a reward (Sailer, Hense, Mandl, & Klevers, 2013).
- (2) *Badges* are defined as visual representations of achievements (Werbach & Hunter, 2012), and can be earned and collected within the gamification environment. They confirm the players' achievements, symbolize their merits (Anderson, Huttenlocher, Kleinberg & Leskovec, 2013), and visibly show their accomplishment of levels or goals (Antin & Churchill, 2011). Earning a badge can be dependent on a specific amount of points or on particular activities within the game (Werbach & Hunter, 2012). Badges have many functions, serving as goals, if the prerequisites for winning them are known to the player, or as virtual status symbols (Werbach & Hunter, 2012; Zichermann & Cunningham, 2011). In the same way as points, badges also provide feedback, in that they indicate how the players have performed (Rigby & Ryan, 2011). In general, badges usually have no

narrative meaning, and collecting them is not compulsory. However, badges can influence players' behavior, leading them to select certain routes and challenges in order to earn the badges that are associated with them (Wang & Sun, 2011). Additionally, as badges symbolize one's membership in a group of those who own this particular badge, they also can exert social influences on players and co-players (Antin & Churchill, 2011; Hamari, 2013), particularly if they are rare or hard to earn.

- (3) *Leaderboards* rank players according to their relative success, measuring them against a certain success criterion (Costa, Wehbe, Robb & Nacke, 2013). As such, leaderboards can help determine who performs best in a certain activity (Crumlish & Malone, 2009), and are thus competitive indicators of progress that relate the player's own performance to the performance of others. However, the motivational potential of leaderboards is mixed. Werbach and Hunter (2012) regard them as effective motivators, if there are only a few points left to the next level or position, but as demotivators, if players find themselves at the bottom end of the leaderboard. Competition caused by leaderboards can create social pressure to increase the player's level of engagement, and can consequently have a constructive effect on participation and learning (Burguillo, 2010). It should be noted, however, that these positive effects of competition are more likely if the respective competitors are approximately at the same performance level (cf. Landers & Landers, 2014; Slavin, 1980).
- (4) *Performance graphs*, which are often used in simulation or strategy games, provide information about the players' performance compared to their preceding performance during a game (Sailer et al., 2013). Thus, in contrast to leaderboards, performance graphs do not compare the player's performance to other players, but instead evaluate the player's own performance over time. Unlike the social reference standard of leaderboards, performance graphs are based on an individual reference standard. By graphically displaying the player's performance over a fixed period, they focus on improvements. Motivation theory postulates that this fosters mastery orientation, which is particularly beneficial to learning (cf. Dweck, 1986; Nicholls, 1984; Sailer et al., 2013).
- (5) *Meaningful stories* are game design elements that do not relate to the player's performance. The narrative context in which a gamified application can be embedded contextualizes activities and characters in the game, and gives them meaning beyond the mere quest for points and achievements (Kapp, 2012). A story can be communicated by a game's title (e.g. *Space Invaders*) or by complex storylines typical of contemporary role-playing video games (e.g. *The Elder Scrolls Series*) (Kapp, 2012). Narrative contexts can be oriented towards real, non-game contexts or act as analogies of real-world settings. The latter can enrich boring, barely stimulating contexts, and, consequently, inspire and motivate players – particularly if the story is in line with their personal interests (Nicholson, 2015). As such, stories are also an important part in gamification applications, as they can alter the meaning of real world activities by adding a narrative 'overlay', e.g. being hunted by zombies while going for a run.
- (6) *Avatars* are visual representations of players within the game or gamification environment (Werbach & Hunter, 2012). Usually they are chosen or even created by the player (Kapp, 2012). Avatars can be designed quite simply as a mere pictogram, or they can be complexly animated, three-dimensional representations. Their main formal requirement is that they unmistakably identify the players and set

them apart from other human or computer-controlled avatars (Werbach & Hunter, 2015). Avatars allow the players to adopt or create another identity and, in cooperative games, to become part of a community (Annetta, 2010).

- (7) *Teammates*, whether they are other real players or virtual non-player characters (NPCs), can induce conflict, competition or cooperation (Kapp, 2012). The latter can be fostered particularly by introducing teams, i.e. by creating defined groups of players that work together towards a shared objective (Werbach & Hunter, 2012).

4. Psychological need satisfaction

In order to analyze and investigate the motivational power of the above-mentioned game design elements, we will now take a closer look at motivation research. Within this field, six principal perspectives can be distinguished that, to a certain degree, become relevant in the context of gamification: the trait perspective, the behaviorist learning perspective, the cognitive perspective, the perspective of self-determination, the perspective of interest, and the perspective of emotion (cf. Astleitner, 2000; Krapp, 1993). Although all these perspectives have implications in regard to the functions and possible effects of gamification (cf. Hense et al., 2014; Sailer et al., 2013), it seems appropriate to focus on one specific perspective for the purposes of empirical investigation. In this paper, we have chosen the self-determination perspective, with which we investigate the effects of the game design elements used in gamification. Our choice is based on the fact that the self-determination perspective encompasses a broad range of motivational mechanisms which partly overlap with several of the other perspectives.

Besides the fact that the perspective of self-determination has already been successfully applied in the context of games (cf. Przybylski, Ryan, & Rigby, 2009; Przybylski, Weinstein, Ryan, & Rigby, 2009; Przybylski et al., 2010; Rigby & Przybylski, 2009; Rigby & Ryan, 2011; Ryan et al., 2006), it also emphasizes the importance of the environment in fostering motivation (Deci & Vansteenkiste, 2004). Enriching the environment with game design elements, as gamification does by definition, directly modifies that environment, thereby potentially affecting motivational and psychological user experiences.

Within self-determination theory, three basic psychological and intrinsic needs are postulated: the need for competence, the need for autonomy, and the need for social relatedness (Deci & Ryan, 1985; Ryan & Deci, 2002; Ryan, 1995).

- (1) *The need for competence* refers to feelings of efficiency and success while interacting with the environment (Rigby & Ryan, 2011; Vansteenkiste & Ryan, 2013; White, 1959). It is assumed that every human strives to feel competent when deliberately influencing the environment they interact with.
- (2) *The need for autonomy* refers to psychological freedom and to volition to fulfill a certain task (van den Broeck, Vansteenkiste, Witte, Soenens, & Lens, 2010; Vansteenkiste, Niemiec, & Soenens, 2010; Vansteenkiste, Williams, & Resnicow, 2012). While psychological freedom refers to the feeling of making decisions on the basis of one's own values and interests (Deci & Ryan, 2012; Ryan & Deci, 2002), volition refers to the feeling of acting without external pressure or enforcement (Vansteenkiste et al., 2010). Therefore, autonomy refers both to experienced (a) *decision freedom*, which implies being able to choose between several courses of action, and experienced (b) *task meaningfulness*, which

implies that the course of action at hand conforms with one's own goals and attitudes.

- (3) *The need for social relatedness* refers to one's feelings of belonging, attachment, and care in relation to a group of significant others. It represents the basic desire of the individual for coherent integration with the social environment (Baumeister & Leary, 1995; Deci & Ryan, 1985, 2000; Deci & Vansteenkiste, 2004).

These three intrinsic psychological needs are motivational resources that can be developed by modifying the environment. Thus, motivational behavior patterns can be promoted to a significant degree by deliberately addressing the human need for competence, autonomy, and social relatedness (Vansteenkiste et al., 2010).

5. Matching psychological needs to game design elements

A basic assumption of this paper is that game design elements can deliberately be used to modify non-game contexts such as working or learning environments, and thus can purposefully address motivational mechanisms. To investigate the effects of such modifications, psychological need satisfaction theory can be applied. From a theoretical perspective, therefore, the emerging question is which specific psychological needs can be addressed by which specific game design elements.

Drawing on the list of game design elements discussed above, we assume that the *need for competence* can be addressed by points, performance graphs, badges, or leaderboards (Hense et al., 2014; Sailer et al., 2013). Points provide the player with granular feedback, which can be directly connected to the actions of the player. Performance graphs visually indicate the player's progress over time, thereby providing sustained feedback. Badges and leaderboards assess a series of player actions and in doing so provide cumulative feedback (cf. Rigby & Ryan, 2011). Thus, essentially, it is the feedback function of these game design elements that can evoke feelings of competence, as this directly communicates the success of a player's actions.

The *need for autonomy* includes two aspects: experiences of decision freedom, and experiences of task meaningfulness. In the first aspect (autonomy in regard to freedom of decision), avatars are relevant, as they offer the players freedom of choice (Annetta, 2010; Peng, Lin, Pfeiffer, & Winn, 2012). In the second aspect (autonomy in regard to task meaningfulness), stories play an important role. Stories can help players experience their own actions as meaningful and volitionally engaging, regardless of whether or not choices are really available (Rigby & Ryan, 2011).

The *need for social relatedness* can also be affected by a story if it offers a narrative frame in which the player is given a meaningful role. Together with teammates, who can be real co-players or non-player characters, a sense of relevance can be evoked by emphasizing the importance of the players' actions for the group's performance (Groh, 2012; Rigby & Ryan, 2011). A shared goal, which can be conveyed within a meaningful story, can also foster experiences of social relatedness (Sailer et al., 2013).

A summary of the above arguments concerning the question of how different psychological needs can be addressed by specific game design elements is shown in Table 1.

Empirical research in regard to the effects of specific game design elements on psychological need satisfaction is still scarce (Mekler et al., 2015; Seaborn & Fels, 2015). However, there are a number of studies that apply this concept, and that investigate the effects of game design elements empirically.

In a series of four empirical studies, Ryan et al. (2006) show that competence, autonomy, and relatedness independently predict both enjoyment and future game-playing behavior. Although this

Table 1
Psychological needs with matching game design elements.

Psychological need	Mechanism	Game design element
Need for competence	Granular feedback Sustained feedback Cumulative feedback Cumulative feedback	Points Performance graphs Badges Leaderboards
Need for autonomy (decision freedom)	Choices	Avatars
Need for autonomy (task meaningfulness)	Volitional engagement	Meaningful stories
Need for social relatedness	Sense of relevance Shared goal	Teammates Meaningful stories

work demonstrates the relevant effects of applying the concept of need satisfaction within the general context of games, it does not contrast different game design elements with one another, which would be necessary for a gamification research perspective (cf. Seaborn & Fels, 2015).

Peng et al. (2012) manipulated certain game features (autonomy-inducing vs. competence-inducing) in a 2×2 design and found corresponding main effects for the manipulated features. Dynamic adjustment of difficulty level and badges led to increased satisfaction of the need for competence. Freedom in regard to avatar customization and choices in autonomous communication style with non-player characters led to increased satisfaction of the need for autonomy.

In contrast to these findings, Mekler et al. (2015) could not observe substantial effects of the game design elements of points, leaderboards, and levels on need satisfaction, although they could observe effects on performance quantity. They explain their findings by arguing that the game design elements applied in their study mainly functioned as extrinsic incentives.

Current research, which is still scarce, thus paints a mixed picture in regard to the effects of game design elements on psychological need satisfaction. Nevertheless, one can generally claim there is a more positive than negative tendency concerning the possibility of deliberately influencing need satisfaction with gamification.

6. A simulation study on the effects of different game design element groups

To test the effects of specific game design elements, grouped in varying configurations, on motivational need fulfilment, we conducted an experimental study in a digital simulation setting. The content domain of the simulation was the internal handling of materials and supplies at production or delivery sites. One central process of internal material handling is order-picking, i.e. the manual collection of delivery parts from a storage depot in response to a customer's orders. Order-picking seemed a suitable task with which to investigate gamification, since, as repetitive work, it is often perceived as neither stimulating nor motivating, and thus has potential for improvement (Hense et al., 2014).

6.1. Questions and hypotheses

The main research interest of our study was to better understand how and to what degree certain game design elements affect psychological need satisfaction. Referring to the above-mentioned theoretical considerations, we investigated the following research questions and hypotheses.

RQ 1. To what extent do game design element groups affect competence need satisfaction?

All gamification elements that provide players with specific

feedback on their performance should evoke feelings of competence. Thus, we expected that badges, leaderboards, and performance graphs would foster experiences of competence. This led to our following hypothesis:

H1. Participants in a game condition with badges, leaderboards, and performance graphs (*experimental condition 1*) experience higher levels of competence than participants in a *control condition*.

RQ 2. To what extent do game design element groups affect autonomy need satisfaction in regard to decision freedom?

One way of offering choices is by using avatars, which are included in a game condition together with a meaningful story, and teammates. We expected that a game condition that includes avatars can cause players to experience feelings of autonomy in regard to decision freedom. This led to the following hypothesis:

H2. Participants in a game condition with avatars, a meaningful story, and teammates (*experimental condition 2*) experience higher levels of decision freedom than participants in a *control condition*.

RQ 3. To what extent do game design element groups affect autonomy need satisfaction in regard to task meaningfulness?

One way of generating meaning within a game is to use a story that embeds the game environment within a larger, fictional narrative. Thus, a story can evoke volitional engagement and subsequent experiences of autonomy in regard to task meaningfulness. This led to the following hypothesis:

H3. Participants in a game condition with avatars, a meaningful story, and teammates (*experimental condition 2*) experience higher levels of task meaningfulness than participants in a *control condition*.

RQ 4. To what extent do game design element groups affect social relatedness need satisfaction?

Playing as part of a team can induce feelings of belonging, and thus contribute to the experience of social relatedness. A suitable story in addition can strengthen these feelings, if it stresses that one's efforts are important to the team's success. This led to the following hypothesis:

H4. Participants in a game condition with avatars, a meaningful story, and teammates (*experimental condition 2*) experience higher levels of social relatedness need satisfaction than participants in a *control condition*.

6.2. Design of the simulation environments

The order-picking process was simulated in a computer-based, cross-platform application, implemented in the Java programming language, and made available on the internet. Within the game environment, players had to collect parts from a storage depot setting, similar to a real life order-picking task in internal

material handling. In total, five orders had to be fulfilled. Each order consisted of three to six parts, which had to be picked from the right places. The simulated storage depot consisted of 10 aisles, with 16 shelves in each aisle and 30 parts on each shelf. An overview of the game environment is shown in Fig. 1. Players see the storage depot setting from a two-dimensional, top-down perspective.

Within the simulated game environment, it was possible to activate various groups of game design elements according to the different experimental conditions. This allowed us to compare these elements with a control condition, and consequently to investigate the effects of specific configurations of game design elements. Three such configurations were implemented as experimental conditions, with participants being randomly assigned to one of these at the start of the game.

In the *control condition*, the only activated game design elements were points. Points, which were also activated in all the other conditions, were deemed essential for the simulation to make any sense to the participants. The control condition is shown in Fig. 1.

Experimental condition 1 included badges, a leaderboard, and a performance graph. Badges could be earned, for example, for fulfilling a certain number of orders within a given time, or for fulfilling orders without making any errors. The leaderboard compared the player's actual score to those of previous players. Finally, performance graphs allowed players to compare their own score over time. These graphs consisted of bar charts which represented the single orders the players had successfully fulfilled.

Experimental condition 2 included avatars, a meaningful story, and teammates. The avatar, which represented futuristic warehouse worker characters, had to be chosen at the beginning of the game. After that, a short narrative story was presented. This embedded the role of the player in a fictional team that had to help stranded people by supplying goods for a relief mission. During

order picking, virtual teammates were visible as computer-controlled NPCs.

6.3. Methods

Participants in the study were recruited online. A total of 699 participants logged in to the online study. $N = 419$ of them completed both the whole game and the whole questionnaire, which was presented to them at the end of the game. Of the participants, 204 (48.7%) were women and 215 (51.3%) were men. The average age was 22 years ($M = 22.39$, $SD = 3.56$).

The questionnaire at the end of the game included items that assessed the psychological need satisfaction of the participants while they were playing. Inspired by the intrinsic motivation inventory (cf. Ryan, Mims, & Koestner, 1983), we included scales to assess psychological need satisfaction in the areas of competence, autonomy in regard to freedom of decision, autonomy in regard to task meaningfulness, and social relatedness. Each of the four variables consisted of three to four items. The items used seven-point Likert scales, each asking participants for their level of agreement with a given statement. Cronbach's α , the total number of items, and a sample item for each variable, are shown in Table 2.

We assumed that the specific gamified features of our simulation could only evoke motivational effects if players were not ignorant of their existence. A meaningful story, for example, which is presented to induce feelings of social relatedness will fail to do so if players skip the relevant screen at the beginning of the game without having read the story. So to ensure that participants were actually aware of all game design elements relevant to the corresponding condition, we conducted a treatment check (or manipulation check, Pedhazur & Schmelkin, 1991) for each element. Our rationale here was that we were not interested in the effectiveness of the gamified features in this particular application, but in

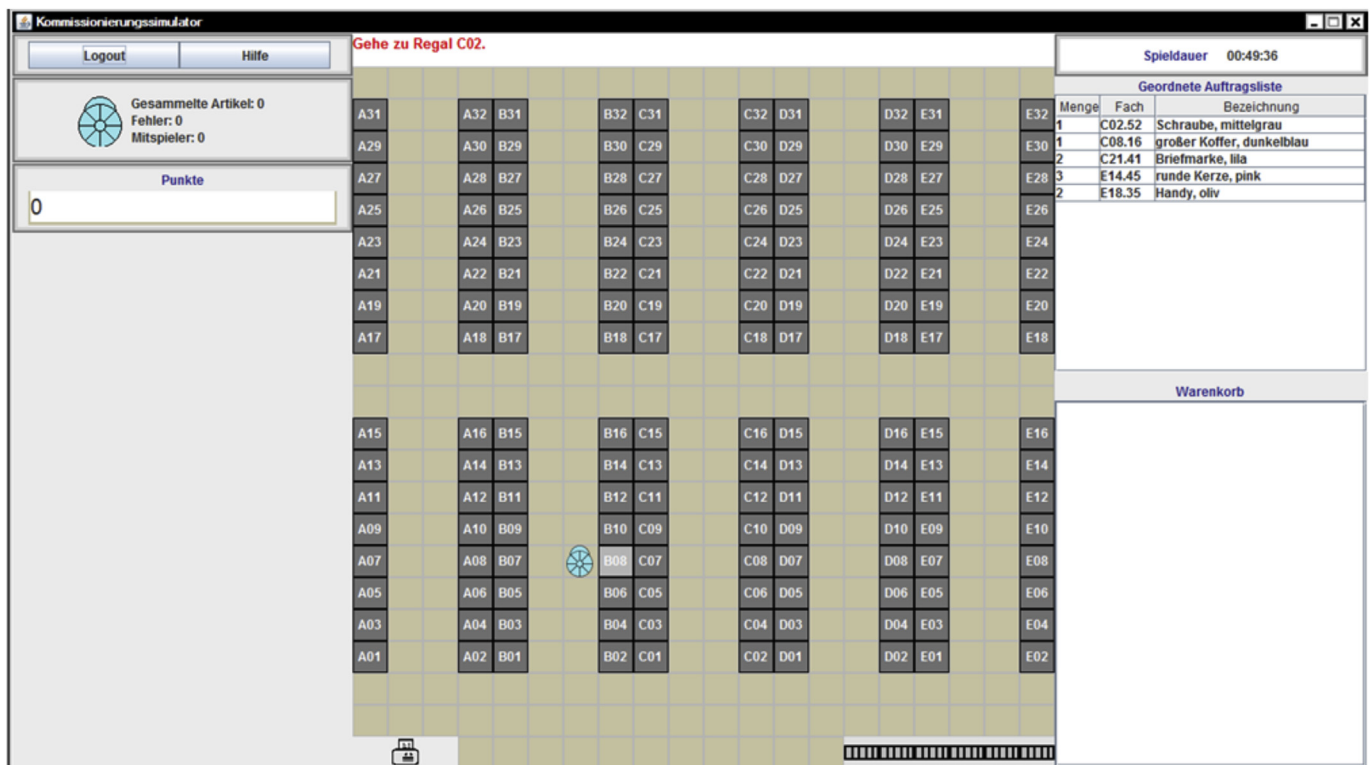


Fig. 1. Game environment, control condition with no game design elements except for points ("Punkte").

Table 2
Assessment of psychological need satisfaction.

Psychological need	Cronbach's α	Number of items	Example item
Competence	$\alpha = .78$	4	While playing I had feelings of success
Autonomy in regard to decision freedom	$\alpha = .90$	3	While playing I could make my own decisions
Autonomy in regard to task meaningfulness	$\alpha = .81$	3	It was worthwhile playing the game
Social relatedness	$\alpha = .79$	3	While playing I felt I was part of a team

arriving at a more generalizable estimate of their potential effectiveness under the premise that players actually recognize them. This reasoning is in alignment with the idea of measuring the integrity of the independent variable, which argues that the experimental manipulation of study participants often cannot be taken for granted (Peterson, Homer, & Wonderlich, 1982) and that it is not enough to deliver a treatment but that one has to make sure that it is also received (Shadish, Cook, & Campbell, 2002). Failing to do so results in a loss of statistical power and the risk to underestimate the potential effectiveness of a treatment (Oppenheimer, Meyvis, & Davidenko, 2009).

To implement the treatment checks, we asked participants in the post-game questionnaire to what degree they had perceived each specific game design element relevant to their experimental condition (e.g. “I read the short narrative introduction at the beginning of the game”). Participants rated these statements on a seven-point agree-disagree answering scale and were excluded from further analysis if they chose the “completely disagree” option. This led to the exclusion of a total of 88 participants, leaving a sample of $N = 331$ participants for statistical analysis, which could be assumed to have recognized the experimental manipulation to a minimal degree at least. Samples for the single groups were $n = 150$ participants for the control group, $n = 103$ participants for the experimental group 1 and $n = 78$ participants for the experimental group 2. This indicates that our simulation was less successful in implementing the gamified features than expected, which constitutes a limitation which we will discuss below.

To analyze the effect of the three experimental conditions on psychological need satisfaction, a single factor, multivariate analysis of variance (MANOVA) and post-hoc Scheffé-tests were calculated.

6.4. Results

The results of the MANOVA are shown in Table 3. The effect size η_p^2 is reported in the last column. The results will be described in more detail for each of our research questions.

RQ1. Regarding *competence need satisfaction*, there was a significant difference between the three conditions ($F(2,328) = 3.39$, $p < .05$, $\eta_p^2 = .020$). The Scheffé post-hoc test indicated a significant difference between participants in the control condition ($M = 3.76$, $SD = 1.36$) and participants in the experimental condition 1 ($M = 4.19$, $SD = 1.35$) in regard to their competence need satisfaction. Accordingly, participants in the game design element

condition with badges, leaderboards, and performance graphs had significantly higher levels of competence need satisfaction than participants in the control condition. This result supports H1.

RQ2. Concerning *autonomy need satisfaction in regard to decision freedom*, there was no significant difference between participation in the three conditions ($F(2,328) = .65$, $p > .05$). H2 could not be confirmed.

RQ3. Concerning *autonomy need satisfaction in regard to task meaningfulness*, there was a significant effect of participation in the three conditions ($F(2,328) = 3.09$, $p < .05$, $\eta_p^2 = .018$). The Scheffé post-hoc test indicated a significant difference between participants in the control condition ($M = 3.65$, $SD = 1.39$) and participants in the experimental condition 1 ($M = 4.06$, $SD = 1.13$), but not between the control and experimental conditions 2. Accordingly, participants in the game design element condition with badges, leaderboards, and performance graphs had significantly higher perceived task meaningfulness than participants in the control condition, while those in the condition including a meaningful story did not. Thus, H3 could not be confirmed.

RQ4. Regarding *social relatedness need satisfaction*, there was a significant effect of participation between the experimental conditions ($F(2,328) = 3.48$, $p < .05$, $\eta_p^2 = .032$). The Scheffé post-hoc test indicated a significant difference between participants in the experimental condition 2 ($M = 1.77$, $SD = .98$), in the control condition ($M = 1.49$, $SD = .90$), and in the experimental condition 1 ($M = 1.45$, $SD = .74$). Participants in the game design element condition with avatars, meaningful stories, and teammates had significantly higher levels of social relatedness need satisfaction than participants in the control condition and participants in the experimental condition 1. Accordingly, H4 could be confirmed.

To sum up, the game design element group with badges, leaderboards, and performance graphs (experimental condition 1) fostered *competence need satisfaction* and *autonomy need satisfaction reading task meaningfulness*. The game design element group with avatars, meaningful stories, and teammates (experimental condition 2) fostered *social relatedness need satisfaction*. However, *autonomy need satisfaction in regard to decision freedom* was not affected by any of the tested game design element groups.

6.5. Discussion

The results of the study indicate that certain game design elements address specific psychological needs, inasmuch as they are

Table 3
Results.

Psychological need satisfaction	Control condition ($n = 150$)	Experimental condition 1 ($n = 103$)	Experimental condition 2 ($n = 78$)	$F(2,328)$	η_p^2
	$M (SD)$	$M (SD)$	$M (SD)$		
Competence	3.76 (1.36)	4.19 (1.35)	4.10 (1.47)	3.39*	.020
Autonomy in regard to decision freedom	3.10 (1.77)	3.16 (1.83)	2.87 (1.65)	.65	.004
Autonomy in regard to task meaningfulness	3.65 (1.39)	4.06 (1.13)	3.91 (1.40)	3.09*	.018
Social relatedness	1.49 (.90)	1.45 (.74)	1.77 (.98)	3.48*	.032

* $p < .05$.

actually recognized by the users. As expected, the group of game design elements with badges, leaderboards, and performance graphs positively affected competence need satisfaction. This is consistent with theoretical considerations about the potential of badges, leaderboards, and performance graphs to act as feedback elements and thereby address experiences of competence (cf. Peng et al., 2012; Rigby & Przybylski, 2009; Rigby & Ryan, 2011; Ryan et al., 2006).

Furthermore, badges, leaderboards, and performance graphs also seemed to contribute to an increase in perceived task meaningfulness. One possible explanation for this unexpected result is that badges, leaderboards, and performance graphs can also create meaning at game level. The game design element group with avatars, meaningful stories and teammates did not affect perceived task meaningfulness. It was expected that the story would render the prescribed path within the game a volitionally engaging experience and thus foster perceived task meaningfulness (cf. Rigby & Ryan, 2011). The story within the study was realized by adding a pop-up with a short text and one comic-style picture. Consequently, it could be speculated that this relatively weak 'dose' may not have been sufficient to elicit the intended effects. The interpretation of results might also suggest that design implementation aesthetics play a major role in the use of game design elements (cf. Mekler et al., 2015).

The game design element group with avatars, meaningful stories, and teammates, on the other hand, did successfully affect experiences of social relatedness. The group of game design elements with avatars, meaningful stories, and teammates introduced a shared goal and led to feelings of relevance (cf. Rigby & Ryan, 2011). In accord with our theoretical considerations, experiences of social relatedness were fostered.

The aspect of perceived decision freedom was not affected by any game design element group. The avatar system, which was activated in the experimental condition 2, did not seem to give the players substantially more perceived choices. This unexpected result might also be explained by a relatively weak 'dose', since, although the avatar symbol was displayed in the game, the choice of an avatar did not affect the game process itself. Decision freedom seemingly depends on more important decision consequences (cf. Peng et al., 2012).

Our results also demonstrate that the awareness of game design elements is crucial and should not be assumed per se. Our treatment check ensured that all participants who were included in statistical analysis actually recognized all the relevant game design elements to some minimal degree at least. Nevertheless, 88 out of 419 participants, who were consequently excluded from statistical analysis, were not aware of the game design elements in their particular condition. This leads to the conclusion that the game design elements were neither self-explanatory for all the participants nor did all the participants even recognize their presence. As similar information on successful experimental manipulation is lacking in other gamification studies, it is hard to say if our simulation environment was particularly unsuccessful in this regard. It seems plausible to explain the results of our manipulation checks to some degree with (unobserved) player characteristics such as concentration, individual preferences, or previous experience with games. Nevertheless it should be considered a limitation of our findings that the effects might be impacted by shortcomings of the implementation of gamification in this particular environment.

7. Outlook

The results of our study are relevant for gamification research in that they address the issue of how different aspects of gamification actually affect different motivational outcomes. Self-determination

theory and psychological need satisfaction are suitable concepts for investigating the effects of different aspects of gamification. The concept of need satisfaction was able to be successfully applied to the concept of gamification. The study also showed that it is worthwhile to investigate autonomy need satisfaction as a two-dimensional construct in the context of gamification, since the game design elements in this study only affected certain aspects of autonomy.

The study addressed the research gap of a lack of experimental designs and the effects of individual game design elements or groups thereof (Bedwell et al., 2012; Hamari, Koivisto, & Sarsa, 2014; Seaborn & Fels, 2015). An additional differentiation of single game design elements should be applied in further studies. Additionally, it is important to investigate game design elements at a surface level, where they can be manipulated independently of one another (cf. Bedwell et al., 2012).

Although a simulation, as used in this study, can only represent certain aspects of reality (Crookall & Saunders, 1989; Garriss et al., 2002; Salen & Zimmerman, 2004), results of such simulations can be applied to real working or learning contexts (Rose & März, 2011). Consequently, an investigation of certain game design element groups within real working or learning contexts would be a logical next step.

Besides the fact that game design elements can address psychological need satisfaction, player awareness in regard to single game design elements must be ensured. Therefore, introductory guides on where to find, how to use, and how to interact with single game design elements could be helpful for certain target groups. Besides this, the effect of game design elements on psychological need satisfaction seems also to depend on the aesthetics and quality of the design implementations. In other words, the whole process of implementing gamification plays a crucial role, as emphasized by Werbach (2014). For this reason, gamification can be a powerful solution to address motivational problems within learning or working contexts, as long as they are well designed and are built upon well-established implementation models.

References

- Anderson, A., Huttenlocher, D., Kleinberg, J., & Leskovec, J. (2013). Steering user behavior with badges. Paper presented at the 22nd international conference on World Wide Web, Rio de Janeiro.
- Annetta, L. A. (2010). The "I's" have it: A framework for serious educational game design. *Review of General Psychology*, 14(2), 105–112. <http://dx.doi.org/10.1037/a0018985>.
- Antin, J., & Churchill, E. F. (2011). Badges in social media: A social psychological perspective. Paper presented at the CHI 2011, Vancouver.
- Arai, S., Sakamoto, K., & Washizaki, H. (2014). A Gamified Tool for Motivating Developers to Remove Warnings of Bug Pattern Tools. Paper presented at the IWSEEP 2014, Osaka. <http://dx.doi.org/10.1109/IWSEEP.2014.17>.
- Astleitner, H. (2000). Designing emotionally sound instruction: The FEASP-approach. *Instructional Science*, 28(3), 169–198.
- Baumeister, R. F., & Leary, M. R. (1995). The need to belong: Desire for interpersonal attachments as a fundamental human motivation. *Psychological bulletin*, 117(3), 497–529. <http://dx.doi.org/10.1037/0033-2909.117.3.497>.
- Bedwell, W. L., Pavlas, D., Heyne, K., Lazzara, E. H., & Salas, E. (2012). Toward a taxonomy linking game attributes to learning: An empirical study. *Simulation & Gaming*, 43(6), 729–760. <http://dx.doi.org/10.1177/1046878112439444>.
- Björk, S., & Holopainen, J. (2004). *Patterns in game design*. Boston, Mass: Charles River Media.
- van den Broeck, A., Vansteenkiste, M., Witte, H., Soenens, B., & Lens, W. (2010). Capturing autonomy, competence, and relatedness at work: Construction and initial validation of the Work-related Basic Need Satisfaction scale. *Journal of Occupational and Organizational Psychology*, 83(4), 981–1002. <http://dx.doi.org/10.1348/096317909x481382>.
- Burguillos, J. C. (2010). Using game theory and Competition-based Learning to stimulate student motivation and performance. *Computers & Education*, 55(2), 566–575. <http://dx.doi.org/10.1016/j.compedu.2010.02.018>.
- Costa, J. P., Wehbe, R. R., Robb, J., & Nacke, L. E. (2013). Time's Up: Studying Leaderboards For Engaging Punctual Behaviour. Paper presented at the Gamification 2013: 1st International Conference on Gameful Design, Research, and Applications, Stratfort. <http://dx.doi.org/10.1145/2583008.2583012>.
- Crookall, D., & Saunders, D. (1989). Towards an integration of communication and

- simulation. In D. Saunders (Ed.), *Communication and Simulation: From two fields to one theme* (pp. 3–29). Clevedon: Multilingual Matters.
- Crumlish, C., & Malone, E. (2009). *Designing social interfaces: Principles, patterns, and practices for improving the user experience*. Sebastopol: O'Reilly Media, Inc.
- Deci, E. L., & Ryan, R. M. (1985). *Intrinsic motivation and self-determination in human behavior*. New York: Springer. <http://dx.doi.org/10.1007/978-1-4899-2271-7>.
- Deci, E. L., & Ryan, R. M. (2000). The "what" and "why" of goal Pursuits: Human needs and the self-determination of behavior. *Psychological Inquiry*, 11(4), 227–268. http://dx.doi.org/10.1207/S15327965PLI1104_01.
- Deci, E. L., & Ryan, R. M. (2012). Motivation, personality, and development within embedded social contexts: An overview of self-determination theory. In R. M. Ryan (Ed.), *The oxford handbook of human motivation* (pp. 1–59). Oxford: Oxford University Press. <http://dx.doi.org/10.1093/oxfordhdb/9780195399820.013.0006>.
- Deci, E. L., & Vansteenkiste, M. (2004). Self-determination theory and basic need satisfaction: Understanding human development in positive psychology. *Ricerche di Psicologia*, 27(1), 23–40.
- Deterding, S., Dixon, D., Khaled, R., & Nacke, L. (2011). From Game Design Elements to Gamefulness: Defining "Gamification". Paper presented at the 15th International Academic MindTrek Conference, Tampere. <http://dx.doi.org/10.1145/2181037.2181040>.
- Deterding, S., Khaled, R., Nacke, L., & Dixon, D. (2011). Gamification: Toward a Definition. Paper presented at the CHI 2011, Vancouver.
- Downes-Le Guin, T., Baker, R., Mechling, J., & Ruyle, E. (2012). Myths and realities of respondent engagement in online surveys. *International Journal of Market Research*, 54(5), 1–21. <http://dx.doi.org/10.2501/IJMR-54-5-613-633>.
- Dweck, C. S. (1986). Motivational processes affecting learning. *American Psychologist*, 41(10), 1040–1048. <http://dx.doi.org/10.1037/0003-066X.41.10.1040>.
- Entertainment Software Association. (2015). *2015: Sales, Demographic and Usage Data - essential facts about the Computer and Video Game Industry*. Retrieved from <http://www.theesaa.com/wp-content/uploads/2015/04/ESA-Essential-Facts-2015.pdf>.
- Farzan, R., & Brusilovsky, P. (2011). Encouraging user participation in a course recommender system: An impact on user behavior. *Computers in Human Behavior*, 27(1), 276–284. <http://dx.doi.org/10.1016/j.chb.2010.08.005>.
- Fernandes, J., Duarte, D., Ribeiro, C., Farinha, C., Pereira, J. M., & Silva, M. M. d (2012). iThink: A game-based approach towards improving collaboration and participation in requirement elicitation. *Procedia Computer Science*, 15, 66–77. <http://dx.doi.org/10.1016/j.procs.2012.10.059>.
- Garris, R., Ahlers, R., & Driskell, J. E. (2002). Games, motivation, and learning: A research and practice model. *Simulation & Gaming*, 33(4), 441–467. <http://dx.doi.org/10.1177/1046878102238607>.
- Gee, J. P. (2007). *Good video games and good learning: Collected essays on video games, learning, and literacy*. New York: Peter Lang International Academic Publishers.
- Groh, F. (2012). Gamification: State of the Art Definition and Utilization. Paper presented at the 4th Seminar on Research Trends in Media Informatics, Ulm.
- Gustafsson, A., Katzeff, C., & Bang, M. (2009). Evaluation of a pervasive game for domestic energy engagement among teenagers. *Computers in Entertainment (CIE)*, 7(4), 54. <http://dx.doi.org/10.1145/1658866.1658873>.
- Hamari, J. (2013). Transforming homo economicus into homo ludens: A field experiment on gamification in a utilitarian peer-to-peer trading service. *Electronic commerce research and applications*, 12(4), 236–245. <http://dx.doi.org/10.1016/j.elerap.2013.01.004>.
- Hamari, J. (2015). Do badges increase user activity? A field experiment on the effects of gamification. *Computers in Human Behavior*. <http://dx.doi.org/10.1016/j.chb.2015.03.036>.
- Hamari, J., Koivisto, J., & Sarsa, H. (2014). Does Gamification Work? - A Literature Review of Empirical Studies on Gamification. Paper presented at the 47th Hawaii International Conference on System Sciences, Waikoloa. <http://dx.doi.org/10.1109/HICSS.2014.377>.
- Hense, J., Klevers, M., Sailer, M., Horenburg, T., Mandl, H., & Günthner, W. (2014). Using gamification to enhance staff motivation in logistics. In S. A. Meijer, & R. Smeds (Eds.), *Frontiers in gaming simulation* (pp. 206–213). Stockholm: Springer. http://dx.doi.org/10.1007/978-3-319-04954-0_24.
- Hense, J., & Mandl, H. (2014). Learning in or with games? Quality criteria for digital learning games from the perspectives of learning, emotion, and motivation theory. In D. G. Sampson, D. Ifenthaler, J. M. Spector, & P. Isaías (Eds.), *Digital systems for open access to formal and informal learning* (pp. 181–193). Piräus: Springer. http://dx.doi.org/10.1007/978-3-319-02264-2_12.
- Jones, B. A., Madden, G. J., & Wengren, H. J. (2014). The FIT game: Preliminary evaluation of a gamification approach to increasing fruit and vegetable consumption in school. *Preventive medicine*, 68, 76–79. <http://dx.doi.org/10.1016/j.ypmed.2014.04.015>.
- Kapp, K. M. (2012). *The gamification of learning and instruction: Game-based methods and strategies for training and education*. San Francisco: Pfeiffer.
- Kelle, S., Klemke, R., & Specht, M. (2013). Effects of game design patterns on basic life support training content. *Journal of Educational Technology & Society*, 16(1), 275–285. <http://dx.doi.org/10.1504/jitel.2011.045452>.
- Krapp, A. (1993). Die Psychologie der Lernmotivation: Perspektiven der Forschung und Probleme ihrer pädagogischen Rezeption. *Zeitschrift für Pädagogik*, 39(2), 187–206.
- Landers, R. N., & Landers, A. K. (2014). An Empirical Test of the Theory of Gamified Learning: The Effect of Leaderboards on Time-on-Task and Academic Performance. *Simulation & Gaming*, 45(6), 769–785. <http://dx.doi.org/10.1177/1046878114563662>.
- Liu, Y., Alexandrova, T., & Nakajima, T. (2011). Gamifying intelligent environments. Paper presented at the 2011 international ACM workshop on Ubiquitous meta user interfaces, Scottsdale. <http://dx.doi.org/10.1145/2072652.2072655>.
- Marczewski, A. (2013). *Gamification: A simple introduction & a bit more - tips, advice and thoughts on gamification* (2. ed.): self-published by Andrzej Marczewski.
- McGonigal, J. (2011). *Reality is Broken: Why games make us better and how they can change the world*. New York: Penguin Group.
- Mekler, E. D., Brühlmann, F., Tuch, A. N., & Opwis, K. (2015). Towards understanding the effects of individual gamification elements on intrinsic motivation and performance. *Computers in Human Behavior*. <http://dx.doi.org/10.1016/j.chb.2015.08.048>.
- Nicholls, J. G. (1984). Achievement motivation: Conceptions of ability, subjective experience, task choice, and performance. *Psychological Review*, 91(3), 328–346. <http://dx.doi.org/10.1037/0033-295X.91.3.328>.
- Nicholson, S. (2015). A RECIPE for meaningful gamification. In T. Reiners, & L. C. Wood (Eds.), *Gamification in education and business* (pp. 1–20). New York: Springer. http://dx.doi.org/10.1007/978-3-319-10208-5_1.
- Oppenheimer, D. M., Meyvis, T., & Davidenko, N. (2009). Instructional manipulation checks: Detecting satisficing to increase statistical power. *Journal of Experimental Social Psychology*, 45(4), 867–872. <http://dx.doi.org/10.1016/j.jesp.2009.03.009>.
- Pedhazur, E. J., & Schmelkin, L. P. (1991). *Measurement, design, and analysis: An integrated approach*. Hillsdale, NJ: Lawrence Erlbaum Associates.
- Peng, W., Lin, J.-H., Pfeiffer, K. A., & Winn, B. (2012). Need satisfaction supportive game features as motivational determinants: An experimental study of a self-determination theory guided exergame. *Media Psychology*, 15(2), 175–196. <http://dx.doi.org/10.1080/15213269.2012.673850>.
- Peterson, L., Homer, A. L., & Wonderlich, S. A. (1982). The integrity of independent variables in behavior analysis. *Journal of applied behavior analysis*, 15(4), 477–492. <http://dx.doi.org/10.1901/jaba.1982.15-477>.
- Przybylski, A. K., Rigby, C. S., & Ryan, R. M. (2010). A motivational model of video game engagement. *Review of General Psychology*, 14(2), 154–166.
- Przybylski, A. K., Ryan, R. M., & Rigby, C. S. (2009). The motivating role of violence in video games. *Personality and Social Psychology Bulletin*, 35(2), 243–259. <http://dx.doi.org/10.1177/0146167208327216>.
- Przybylski, A. K., Weinstein, N., Ryan, R. M., & Rigby, C. S. (2009). Having to versus wanting to play: Background and consequences of harmonious versus obsessive engagement in video games. *CyberPsychology & Behavior*, 12(5), 485–492. <http://dx.doi.org/10.1089/cpb.2009.0083>.
- Reeves, B., & Read, J. L. (2009). *Total Engagement: Using games and virtual worlds to change the way people work and businesses compete*. Boston: Harvard Business School Press.
- Rigby, C. S., & Przybylski, A. K. (2009). Virtual worlds and the learner hero: How today's video games can inform tomorrow's digital learning environments. *Theory and Research in Education*, 7(2), 214–223. <http://dx.doi.org/10.1177/1477878509104326>.
- Rigby, C. S., & Ryan, R. M. (2011). *Glued to games: How video games draw us in and hold us spellbound*. Santa Barbara: Praeger.
- Robinson, D., & Bellotti, V. (2013). A Preliminary Taxonomy of Gamification Elements for Varying Anticipated Commitment. Paper presented at the CHI 2013, Paris.
- Rose, O., & März, L. (2011). Simulation. In L. März, W. Krug, O. Rose, & G. Weigert (Eds.), *Simulation und Optimierung in Produktion und Logistik* (pp. 13–20). Berlin: Springer. http://dx.doi.org/10.1007/978-3-642-14536-0_2.
- Ryan, R. M. (1995). Psychological needs and the facilitation of integrative processes. *Journal of personality*, 63(3), 397–427. <http://dx.doi.org/10.1111/j.1467-6494.1995.tb00501.x>.
- Ryan, R. M., & Deci, E. L. (2002). Overview of self-determination theory: An organismic dialectical perspective. In R. M. Ryan, & E. L. Deci (Eds.), *Handbook of self-determination research* (pp. 3–33). Rochester: University of Rochester Press.
- Ryan, R. M., Mims, V., & Koestner, R. (1983). Relation of reward contingency and interpersonal context to intrinsic motivation: A review and test using cognitive evaluation theory. *Journal of Personality and Social Psychology*, 45(4), 736–750. <http://dx.doi.org/10.1037/0022-3514.45.4.736>.
- Ryan, R. M., Rigby, C. S., & Przybylski, A. K. (2006). The motivational pull of video games: A self-determination theory approach. *Motivation and Emotion*, 30(4), 344–360. <http://dx.doi.org/10.1007/s11031-006-9051-8>.
- Sailer, M., Hense, J., Mandl, H., & Klevers, M. (2013). Psychological perspectives on motivation through gamification. *Interaction Design and Architecture(s) Journal*, 19, 28–37.
- Salen, K., & Zimmerman, E. (2004). *Rules of Play: Game design fundamentals*. Cambridge: MIT Press.
- Schunk, D. H., Pintrich, P. R., & Meece, J. L. (2010). *Motivation in education: Theory, research, and applications* (3 rd ed.). Upper Saddle River: Pearson.
- Seaborn, K., & Fels, D. I. (2015). Gamification in theory and action: A survey. *International Journal of Human-Computer Studies*, 74, 14–31. <http://dx.doi.org/10.1016/j.ijhcs.2014.09.006>.
- Shadish, W. R., Cook, T. D., & Campbell, D. T. (2002). *Experimental and quasi-experimental designs for generalized causal inference*. Boston: Houghton Mifflin.
- Shi, L., Cristea, A. I., Hadzidedic, S., & Dervishalidovic, N. (2014). Contextual gamification of social interaction – towards increasing motivation in social e-learning. In E. Popescu, R. H. Lau, K. Pata, H. Leung, & M. Laanpere (Eds.), *Advances in web-based learning – ICWL 2014* (pp. 116–122). Tallinn: Springer. http://dx.doi.org/10.1007/978-3-319-09635-3_12.

- Slavin, R. E. (1980). Cooperative learning. *Review of Educational Research*, 50(2), 315–342. <http://dx.doi.org/10.3102/00346543050002315>.
- Vansteenkiste, M., Niemiec, C. P., & Soenens, B. (2010). The development of the five mini-theories of self-determination theory: An historical overview, emerging trends, and future directions. In T. C. Urdan, & S. A. Karabenick (Eds.), *The decade Ahead: Theoretical perspectives on motivation and achievement (advances in motivation and achievement* (Vol. 16 A, pp. 105–165). London: Emerald Group Publishing Limited. [http://dx.doi.org/10.1108/s0749-7423\(2010\)000016a007](http://dx.doi.org/10.1108/s0749-7423(2010)000016a007).
- Vansteenkiste, M., & Ryan, R. M. (2013). On psychological growth and vulnerability: Basic psychological need satisfaction and need frustration as a unifying principle. *Journal of Psychotherapy Integration*, 23(3), 263–280. <http://dx.doi.org/10.1037/a0032359>.
- Vansteenkiste, M., Williams, G. C., & Resnicow, K. (2012). Toward systematic integration between self-determination theory and motivational interviewing as examples of top-down and bottom-up intervention development: Autonomy or volition as a fundamental theoretical principle. *International Journal of Behavioral Nutrition and Physical Activity*, 9(23). <http://dx.doi.org/10.1186/1479-5868-9-23>.
- Wang, H., & Sun, C.-T. (2011). Game reward systems: gaming experiences and social meanings. Paper presented at the DiGRA 2011 conference: Think Design Play, Hilversum.
- Werbach, K. (2014). (Re)defining gamification: A process approach. In A. Spagnolli, L. Chittaro, & L. Gamberini (Eds.), *Persuasive technology* (Vol. 8462, pp. 266–272). Springer. http://dx.doi.org/10.1007/978-3-319-07127-5_23.
- Werbach, K., & Hunter, D. (2012). *For the Win: How game thinking can revolutionize your business*. Philadelphia: Wharton Digital Press.
- Werbach, K., & Hunter, D. (2015). *The gamification toolkit - dynamics, mechanics, and components for the win*. Philadelphia: Wharton Digital Press.
- White, R. W. (1959). Motivation reconsidered: The concept of competence. *Psychological review*, 66(5), 297–333. <http://dx.doi.org/10.1037/h0040934>.
- Yee, N. (2006). Motivations for play in online games. *CyberPsychology & Behavior*, 9(6), 772–777. <http://dx.doi.org/10.1089/cpb.2006.9.772>.
- Yongwen, X., Johnson, P., Moore, C. A., Brewer, R. S., & Takayama, J. (2013). SGSEAM: Assessing Serious Game Frameworks from a Stakeholder Experience Perspective. Paper presented at the Gamification 2013: 1st International Conference on Gameful Design, Research, and Applications, Stratfort. <http://dx.doi.org/10.1145/2583008.2583018>.
- Zichermann, G., & Cunningham, C. (2011). *Gamification by Design: Implementing game mechanics in web and mobile apps*. Sebastopol: O'Reilly Media.
- Zichermann, G., & Linder, J. (2010). *Game-based Marketing: Inspire customer loyalty through rewards, challenges, and contests*. New Jersey: Wiley.
- Zichermann, G., & Linder, J. (2013). *The gamification revolution*. New York: McGraw-Hill Education.