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Gamified Crowdsourcing: Conceptualization, Literature Review, and Future Agenda

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ABSTRACT

Two parallel phenomena are gaining attention in human-computer interaction research: gamification and crowdsourcing. Because crowdsourcing's success depends on a mass of motivated crowdsourcees, crowdsourcing platforms have increasingly been imbued with motivational design features borrowed from games; a practice often called *gamification*. While the body of literature and knowledge of the phenomenon have begun to accumulate, we still lack a comprehensive and systematic understanding of conceptual foundations, knowledge of how gamification is used in crowdsourcing, and whether it is effective. We first provide a conceptual framework for gamified crowdsourcing systems in order to understand and conceptualize the key aspects of the phenomenon. The paper's main contributions are derived through a systematic literature review that investigates how gamification has been examined in different types of crowdsourcing in a variety of domains. This meticulous mapping, which focuses on all aspects in our framework, enables us to infer what kinds of gamification efforts are effective in different crowdsourcing approaches as well as to point to a number of research gaps and lay out future research directions for gamified crowdsourcing systems. Overall, the results indicate that gamification has been an effective approach for increasing crowdsourcing participation and the quality of the crowdsourced work; however, differences exist between different types of crowdsourcing: the research conducted in the context of crowdsourcing of homogenous tasks has most commonly used simple gamification implementations, such as points and leaderboards, whereas crowdsourcing implementations that seek diverse and creative contributions employ gamification with a richer set of mechanics.

Keywords: gamification, crowdsourcing, literature review, research agenda, human computation, persuasive technology

1 INTRODUCTION

During recent years, modern ICT technologies have spawned two parallel phenomena: gamification and crowdsourcing. Today, many different organizations employ crowdsourcing as a way to outsource various tasks to be carried out by 'the crowd': a mass of people reachable through the Internet (Howe, 2006). The rapid diffusion of these technologies can be seen both in practice and in academia (Estellés-Arolas and González-Ladrón-de-Guevara, 2012; Hamari et al., 2014; IEEE, 2014; Seaborn and Fels, 2015). As of December 2015, almost 3,000 crowdsourcing-related examples are listed at crowdsourcing.org, a leading crowdsourcing industry portal. In parallel, business analysts have estimated that at least 50% of all organizations that manage innovation processes have gamified some of their processes by 2015 (Gartner, 2011). The primary general goals of crowdsourcing are either cost savings or the possibility to handle tasks that would be difficult to perform without human support. However, crowdsourcing relies on the existence of a reserve of people willing to take on tasks for free or for little monetary compensation. Along this reasoning, crowdsourcing systems are increasingly *gamified* (Hamari et al., 2014; Seaborn and Fels, 2015), that is, organizations seek to make the crowdsourced work activity more like playing a game in order to provide other motives for working than just monetary compensation. Such gamified crowdsourcing systems are increasing, and are a major application area of gamification (Hamari et al., 2014).

However, while the new phenomenon seems intuitively appealing, there is little coherent understanding of the characteristic features of gamified crowdsourcing systems. Although there are singular scattered empirical pieces on the topic, no efforts have yet been made to collate and synthesize this body of knowledge. Further, both crowdsourcing and gamification can take a variety of forms, and it would be myopic to assume that differing gamification implementations would function similarly across different crowdsourcing approaches. This lack of comprehensive understanding of the phenomenon inhibits us from designing effective incentive systems for crowdsourcing and therefore to optimally harness the potential of the crowd and to derive the most successful solutions and innovations.

In this paper, we provide a comprehensive review, overview, and future outlook on the usage and study of gamification in crowdsourcing systems. We first provide an integrated conceptual framework

for gamified crowdsourcing systems (Figure 3), based on the extant literature on crowdsourcing (Geiger and Schader, 2014; Prpić et al., 2015) and gamification (Hamari et al., 2014; Seaborn and Fels 2015). This framework remedies existing conceptual hurdles and scantness in how gamification, crowdsourcing, and their combinations are generally perceived, and acts both as a framework to direct this review and as an anchor point for further studies. The primary contribution of the paper is a systematic literature review of 110 papers that investigates how gamification is being studied and implemented in crowdsourcing research. Specifically, we review the use of different forms of gamification in different types of crowdsourcing, as well as the interplay of gamification and monetary rewards, the types of work being crowdsourced, the types of crowdsourcees, the domains where gamification in crowdsourcing have been applied, and empirical results of studies on the effectiveness of gamification in crowdsourcing. This meticulous mapping enables us to 1) infer what kinds of gamification efforts are effective in different kinds of crowdsourcing approaches, 2) derive recommendations for designers of gamified crowdsourcing systems, and 3) outline a research agenda for future research.

2 CONCEPTUAL FOUNDATIONS

2.1 Crowdsourcing

Generally, crowdsourcing can be seen as an online, distributed problem-solving approach that transforms *problems and tasks* into *solutions* by harnessing the potential of large groups of *crowdsourcees* via the Web rather than traditional employees or suppliers (Brabham, 2008a; Doan et al., 2011; Estellés-Arolas and González-Ladrón-de-Guevara, 2012; Howe, 2006; Nakatsu et al., 2014; Pedersen et al., 2013; Prpić et al., 2015; Zuchowski et al., 2016). Via the rise of online collaboration technologies and Web2.0, it has become fairly easy to reach large groups of people. Thus, the concept of crowdsourcing has become increasingly popular (Gatautis and Vitkauskaite, 2014; Geiger and Schader, 2014; Rouse, 2010; Zuchowski et al., 2016). There has been an increase in the number of startups with crowdsourcing-based business models (Brabham, 2010, 2008b) and many companies have begun to invest in internal and external crowdsourcing (Leimeister et al., 2009; Schlagwein and Bjørn-Andersen, 2014; Zuchowski et al., 2016). Crowdsourcing is considered a particularly useful way to

coordinate work for tasks that can benefit from collective intelligence (Leimeister, 2010) or that are hard to process by computers and are therefore outsourced to people (Von Ahn, 2009).

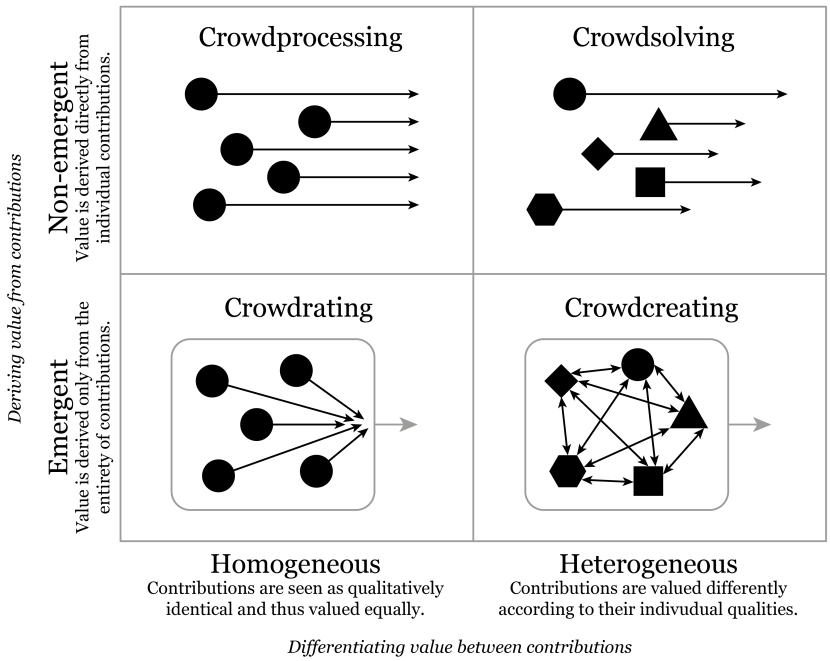

Figure 1. Four Archetypes of Crowdsourcing Systems (based on Geiger and Schader, 2014)

Following the conceptual works of Geiger and Schader (2014) and Prpić et al. (2015)[1], crowdsourcing systems can be categorized into four categories, depending on the characteristics of the crowdsourced *work* (see Figure 1). First, *crowdprocessing* approaches rely on the crowd to perform large quantities of homogeneous tasks. Identical contributions are a quality attribute of the work's validity. The value is derived directly from each isolated contribution (non-emergent) (e.g. Mechanical Turk or Galaxy Zoo) (Lintott et al., 2008). Second, *crowdsolving* approaches use the diversity of the crowd to find a huge number of heterogeneous solutions to a given problem. The value of this approach results directly from each isolated contribution (non-emergent). Crowdsolving is often used for very complex problems (e.g. Foldit, a game-based approach to optimize protein folding) (Cooper et al., 2010) or if no pre-definable solution exists (e.g. ideation contests). Third, *crowdrating* systems commonly seek to harness the so-called *wisdom of crowds* (Surowiecki, 2005) to perform collective assessments or predictions. In this case, the emergent value arises from a huge number of homogeneous 'votes' (e.g.

[1] The frameworks of Geiger and Schader (2014) as well as Prpić et al. (2015) classify crowdsourcing into four categories that are comparable at their core. For clarity, we employed Geiger and Schader's (2014) terminology.

NASA Clickworkers, in which the clicks/votes of a crowd were used to identify craters on asteroids) (Kanefsky et al., 2001). Fourth, *crowdcreating* solutions seek to create comprehensive (emergent) artifacts based on a variety of heterogeneous contributions. Typical examples include all kinds of user-generated content (e.g. YouTube) or knowledge derived from collaborative aggregation (e.g. Wikipedia).

2.2 Gamification

Since an active crowd of participants is crucial for successful crowdsourcing, the motivation of *crowdsourcees* is crucial (Zhao and Zhu, 2014a). Although much research has been done in the area of crowdsourcing, only a few studies have comprehensively investigated participants' motivations (e.g. Brabham, 2010, 2008b; Kaufmann et al., 2011; Zhao and Zhu, 2014b; Zheng et al., 2011) and incentive design (e.g. Harris et al., 2015; Leimeister et al., 2009; Straub et al., 2015). Studies have shown that a wide variety of reasons and motivations, ranging from intrinsic to extrinsic, lead people to participate in crowdsourcing and related online work and economic coordination (Hamari et al., 2016; Kaufmann et al., 2011; Straub et al., 2015; Zhao and Zhu, 2014b; Zheng et al., 2011). For instance, intrinsic motivation – caused by tasks that allow a participant to be creative and experience autonomy, to develop own skills and feel competent, to enjoy a pastime, or to achieve social recognition – can in some cases be dominated by extrinsic motivation evoked by financial payoffs or external social reasons (Kaufmann et al., 2011). Further, task characteristics (Kaufmann et al., 2011; Zheng et al., 2011), task granularity (Nakatsu et al., 2014; Zhao and Zhu, 2014b), or perceived motivational affordances (Zhao and Zhu, 2014b) can further influence an individual's motivation.

Thus, one major challenge in motivating people to participate is to design a crowdsourcing system that promotes and enables the formation of positive motivations towards crowdsourcing work and fits the type of the activity. For instance, while some crowdsourcing approaches aim for systematically derived contributions, others may call for incentive structures that promote creativity. In other words, since crowdsourcing activities can differ dramatically, so can the means to motivate crowdsourcees in a crowdsourcing initiative.

In incentive design, an important part of human-computer interaction research, one of the most popular developments in recent years has commonly been called *gamification* (Hamari et al., 2014; Hamari et al., 2015; Seaborn and Fels 2015). Gamification refers to design that seeks to, first, increase the motivation of users or participants to engage in an activity or behavior and, second, to increase or otherwise change a given behavior. The concept of gamification stems from the notion that games are a pinnacle form of hedonic self-purposeful systems (Hamari and Koivisto, 2015a). Most gamification applications borrow design patterns from (video) games, and, consequently, aim to give rise to similar experiences as games commonly do, for instance, feelings of mastery, autonomy, flow, or suspense (see e.g. Huotari and Hamari, 2016; Seaborn and Fels, 2015). If we consider gamification in the context of crowdsourcing, it can be seen as an attempt to redirect crowdsourcees' motivations from purely rational gain-seeking to self-purposeful, intrinsically motivated activity: "Transforming Homo Economicus into Homo Ludens" (Hamari, 2013). Through this redirection of motivations, the goal is to influence crowdsourcees' behaviors (e.g. participation, concentration, work duration, engagement, or work quality) in the execution of the crowdsourced *work*. In other words, elements known from games act as motivational affordances (Huotari and Hamari, 2016; Jung et al., 2010; Zhang, 2008) for intrinsic motivations. Points, badges, leaderboards, avatars, and stories are frequently used motivational affordances in gamification (Hamari et al., 2014). The extant literature has conceptualized gamification into a few key aspects: 1) the design (*gamification affordances*), 2) the *psychological outcomes* of gamification, and 3) the *behavioral outcomes* of gamification (Huotari and Hamari, 2016) (Figure 2). As in classical, non-gamified crowdsourcing systems, gamification can be combined with *additional incentives*, typically monetary rewards, for instance, piece rate payments or a tournament prize that might have additional effects on crowdsourcees' motivations (Straub et al., 2015; Zhao and Zhu, 2014a). Existing empirical works also suggest that contextual factors, such as the domain (Hamari, 2013), and aspects relating to the user, have an effect (Koivisto and Hamari, 2014).

Gamification has thus far been researched in a variety of areas, such as health (Jones et al., 2014), exercise (Hamari and Koivisto, 2014, 2015a, 2015b; Chen and Pu, 2014; Koivisto and Hamari, 2014), education (Bonde et al., 2014; Christy and Fox, 2014; Domínguez et al., 2013; De-Marcos et al., 2014;

Denny, 2013; Morschheuser et al., 2014), commerce (Hamari, 2013, 2015), intra-organizational communication and activities (Morschheuser et al., 2017, 2015), government services (Bista et al., 2014), public engagement (Tolmie et al., 2013), environmental behavior (J. J. Lee et al., 2013; Lounis et al., 2014), and marketing and advertising (Terlutter and Capella, 2013; Cechanowicz et al., 2013). A review on empirical studies on gamification (Hamari et al., 2014) indicated that most gamification studies reported positive effects from the gamification implementations. However, there is still a sizeable gap in our knowledge on the effectiveness of gamification in crowdsourcing, how the results pertaining to gamification differ across domains, which gamification strategies have been used in which environments and towards which kinds of goals. Even though crowdsourcing systems are one of the most researched application areas of gamification (Hamari et al., 2014), the literature is currently fragmented, and no comprehensive conceptualization of gamified crowdsourcing systems exist.

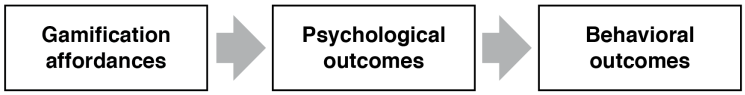

Figure 2. Abstract conceptualization of gamification according to Hamari et al. (2014); Huotari and Hamari (2016)

2.3 An integrated conceptual framework for gamified crowdsourcing systems

To map the existing literature on gamified crowdsourcing, conceptualizations are needed to guide the mapping so that all the key aspects can be accounted for. Thus, by building on existing work on crowdsourcing (Geiger and Schader, 2014; Pedersen et al., 2013; Zuchowski et al., 2016) and gamification (Hamari et al., 2014) above, we suggest an integrated conceptual framework (as depicted in Figure 3). The framework represents all core aspects of gamified crowdsourcing systems outlined above and provides structure to investigate the phenomenon holistically, along its key components. Our literature review is guided by this framework and investigates both the empirical results on the effectiveness of gamification in crowdsourcing, as well as the variety of concrete manifestations of gamified crowdsourcing systems in the current literature, with a focus on incentive orchestrations of gamification affordances and additional (i.e. monetary) rewards that could lead to several motivational and behavioral outcomes.

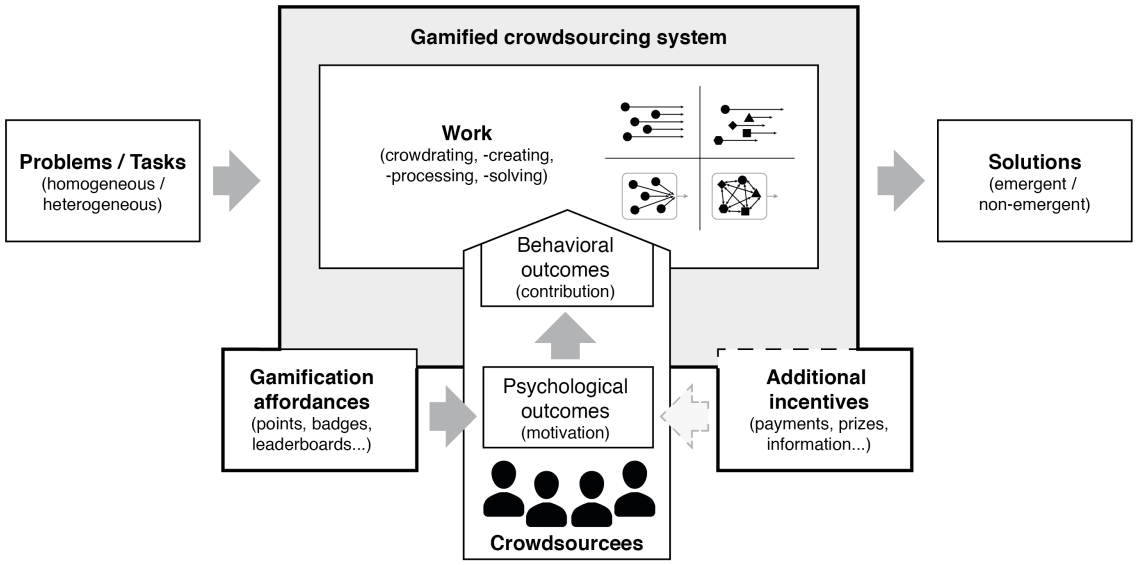

Figure 3. Conceptual Framework of Gamified Crowdsourcing Systems

3 RESEARCH METHODOLOGY

Following the guidelines of Webster and Watson (2002), Boell and Cecez-Kecmanovic (2015), and Ellis (2010), we began the literature review with a literature search. We used the Scopus database as our source of data, since it indexes all other potentially relevant databases, for instance, ACM, IEEE, Springer, and the DBLP Computer Science Bibliography. Since all these individual databases differ in their search functions and algorithms, focusing the search on only one database has ensured that the procedure is replicable, rigorous, and transparent (Boell and Cecez-Kecmanovic, 2015).

The literature search in the Scopus database was conducted in October 2016 using the search query TITLE-ABS-KEY(GAMIF* AND CROWD*). The results included any permutation of the terms *gamification* and *crowdsourcing* in the entry metadata (title, abstract, or keywords). We intentionally limited the search to the metadata, since searching for the terms in all the text would result in a relatively large amount of false positives, since many papers refer to gamification and/or crowdsourcing in passing. We did not restrict the search to specific outlets or disciplines, for two reasons. First, crowdsourcing is a socio-technical approach and is therefore applied in various contexts. Second, due to the novelty of the

gamification phenomena, most of the studies have not yet found their way into high-quality journals and are published in peer-reviewed conferences instead.

The Scopus search query resulted in 145 hits. These hits contained 16 conference reviews and summaries, which have been excluded since they provide no self-contained research contribution. Further, a preliminary conference paper version of the present study was ignored resulting in a repertoire of 128 hits (for a full list, see the Appendix). We then screened these papers for inclusion and relevance, using the following criteria: 1) the full paper can be acquired; 2) the paper is in English (and has been published by an international venue); 3) gamification and crowdsourcing must have a significant/relevant role in the paper instead of just being mentioned in the metadata; 4) the paper is not a duplicate that reports the same study in several papers. This screening process was performed by all of the authors as a team. As a result of this screening, one paper was excluded due to the full paper not being available, and another for not being in English. Further, we excluded 14 papers from the review, since gamified crowdsourcing was not actually relevant in these papers' content. Moreover, in two cases, duplicates were found. For instance, Y. Liu, Alexandrova, and Nakajima (2011) and Y. Liu, Alexandrova, Nakajima et al. (2011) describe the same experiment and report similar results. Thus, we merged the information of the two papers and handled them in the analyses as one entity. Finally, 110 papers were chosen for inclusion in the literature review.

In the next step of the literature analysis, we coded the included papers (Webster and Watson, 2002). First, we gathered information of all the papers pertaining to 1) bibliometric information (authors, years, publication venues, publications types, disciplines), 2) the type of study (conceptual, empirical, research-in-progress), and 3) domain. Using our framework presented in Figure 3, we collected 4) the different characteristics of gamified crowdsourcing systems, including the work type, the crowdsourcing type, gamification affordances and mechanisms used, the incentive orchestration, and the type of crowdsourcees. Finally, 5) we accumulated the results of empirical studies on the psychological and behavioral outcomes of gamified crowdsourcing systems and gamification's overall effectiveness in crowdsourcing. Based on the coded literature data, we analyzed the results in accordance with Webster and Watson (2002) and compounded the data into frequency tables.

4 RESULTS

4.1 Bibliometric information

As a first step in the analysis, we examined the bibliometric data of the 110 included papers. The first study to combine both gamification and crowdsourcing was already published in 2011. While three papers were published in 2012, research on the concepts began to increase in 2013 (15 papers). Up to October 2016, when the search was conducted, the number of papers has been constantly growing (2014: 29 papers; 2015: 41 papers; first half of 2016: 21 papers). The vast majority of these publications are conference papers and workshop papers (Table 1), which is in line with the novelty of the perspective; the reviewed studies were largely exploratory and preliminary works on the topic. However, an increasing number of high-quality journal publications and book chapters can be recognized (2014: 1 paper; 2015: 21 papers; first half of 2016: 11 papers).

Table 1. Publication Types of the Reviewed Papers

Publication type	Frequency	%
Full conference paper	59	53.6
Workshop paper / poster	22	20.0
Journal article / article in press	21	19.1
Short conference paper	5	4.5
Book chapter	3	2.7
Total	**110**	**100**

Concerning the disciplines under which research on the topic was conducted, 84 of the studies had been published in venues and journals related to HCI and computer science. In addition, 9 papers were published on information retrieval-related forums. The rest were published in venues relating to economics (2), engineering (2), cartography (2), IT education (2), communication (1), innovation management (1), electronics (1), librarianship (1), musicology (1), physics (1), media production (1), bioinformatics (1), and social science (1).

4.2 Descriptive information

Beyond bibliometric information, we analyzed the frequency of types of the studies in the body of literature. As reported in Table 2, of the 110 reviewed studies, 63 were empirical. Of these, 37 papers studied the effects of gamification in crowdsourcing, while 25 studies empirically investigated other aspects relating to crowdsourcing and gamification. Beyond the empirical studies, 29 papers merely included preliminary descriptions of a future study or a description of a gamified crowdsourcing system. The body of literature contained 18 conceptual papers.

Table 2. Study Types

Type of study	Papers	Frequency	%
Empirical studies with results on how gamification works in crowdsourcing	Altmeyer et al., 2016; Bowser et al., 2013; Carlier et al., 2016; De Franga et al., 2015; Dergousoff and Mandryk, 2015; Choi et al., 2014; Dumitrache et al., 2013; Eickhoff et al., 2012; Feyisetan et al., 2015; Goncalves et al., 2014; Ipeirotis and Gabrilovich, 2014; Itoko et al., 2014; Kacorri et al., 2015; Kawajiri et al., 2014; Kobayashi et al., 2015; J. J. Lee et al., 2013; T. Y. Lee et al., 2013; Y. Liu, Alexandrova, Nakajima et al., 2011; Machnik et al., 2015; Martella et al., 2015; Massung et al., 2013; Melenhorst et al., 2015; Nose and Hishiyama, 2013; Packham and Suleman, 2015; Pothineni et al., 2014; Prandi et al., 2016; Preist et al., 2014; Prestopnik and Tang, 2015; Roengsamut et al., 2015; Runge et al., 2015; Saito et al., 2014; Simões and De Amicis, 2016; Snijders et al., 2015; Sørensen et al., 2016; Talasila et al., 2016; Tinati et al., 2016; Vasilescu et al., 2014	37	33.6
Empirical studies with no results on how gamification works in crowdsourcing	Bentzien et al., 2013; Brenner et al., 2014; Brito et al., 2015; Cao et al., 2015; Chamberlain, 2014; Cucari et al., 2016; Deng et al., 2016; Dos Santos et al., 2015; Harris, 2014; He et al., 2014; Inaba et al., 2015; Kacorri et al., 2014; Kurita et al., 2016; Lauto and Valentin, 2016; Lessel et al., 2015; Mason et al., 2012; Nagai et al., 2014; Nunzio et al., 2016; Riegler et al., 2015; Rosani et al., 2015; Sakamoto and Nakajima, 2014; Sheng, 2013; Ustalov, 2015; Uzun et al., 2013; Yakushin and Lee, 2014; ; Yu et al., 2015	26	23.6
(Preliminary) description of a study or a system; no empirical results	Ahmed and Mueller, 2014; AlRouqi and Al-Khalifa, 2014; Ansari et al., 2013; Bainbridge, 2015; Benjamin, 2016; Biegel et al., 2014; Bockes et al., 2015; Burnett et al., 2012; Fava et al., 2015; Fedorov et al., 2016; Hammais et al., 2014; Hantke et al., 2015; Marasco et al., 2015; McCartney et al., 2015; Mizuyama and Miyashita, 2016; Moreno et al., 2015; Netek and Panek, 2016; Panchariya et al., 2015; Pinto and Viana, 2015; Prandi et al., 2015; Roa-Valverde, 2014; Silva and Lopes, 2016; Smith and Kilty, 2014; Stannett et al., 2013; Supendi and Prihatmanto, 2015; Supriadi and Prihatmanto, 2015; Susumpow et al. 2014; Wu and Luo, 2014; Xie et al., 2015	29	26.4
Conceptual, frameworks	Armisen and Majchrzak, 2015; Brandtner et al., 2014; Cherinka et al., 2013; Dai et al., 2016; Greenhill et al., 2016; Katmada et al., 2016; LaToza et al., 2013; Mahnič, 2014; Nakatsu and Iacovou, 2014; Reid, 2013; Reinsch et al., 2013; Roth et al., 2015; Sakamoto et al., 2016; Sigala, 2015; Simões et al., 2015; Simperl, 2015; Snijders et al., 2014; Wang et al., 2015	18	16.4
Total		**110**	**100**

Regardless of the wide spectrum of the domains in which research on crowdsourcing is being conducted, the entire body of literature indicates that crowdsourcing is always information-intensive

and relates to some form of information processing or retrieval: solving, creating, processing, and rating. Gamified crowdsourcing is often applied to elicit information about an environment. Such studies commonly contain gathering, recognizing and classifying biological (Ansari et al., 2013; Bowser et al., 2013; Prestopnik and Tang, 2015) and environment-related data (Mason et al., 2012), as well as promoting environmental behavior (J. J. Lee et al., 2013; Massung et al., 2013; Preist et al., 2014). We also identified that gamified crowdsourcing is popular in the context of digital cartography and navigation. The latter type of studies featured, for instance, the creation of digital maps based on user-reported data, the gathering of location-based sensory data (Kawajiri et al., 2014; Wang et al., 2015), location measurements (Uzun et al., 2013), geospatial information (Goncalves et al., 2014), and (indoor) navigation information (Bockes et al., 2015; Reinsch et al., 2013). Furthermore, as reported in Table 3, the domains of language-related information (e.g. proofreading, translation, etc.), innovation, and software development (e.g. the development of code fragments or requirement elicitation) were also among the most common contexts for gamified crowdsourcing. A rising trend during the past few years in gamified crowdsourcing has been the gathering of datasets for machine learning approaches. Overall, the application of gamified crowdsourcing is far-reaching and involves a variety of contexts, from information retrieval for entertainment purposes (Bainbridge, 2015; Pinto and Viana, 2015), to the solving of physical problems (Sørensen et al., 2016).

Table 3. Domains

Domain	Papers	Frequency
General crowdsourcing (no specific domain)	Ahmed and Mueller, 2014; Brenner et al., 2014; Carlier et al., 2016; Choi et al., 2014; Dai et al., 2016; Dergousoff and Mandryk, 2015; Eickhoff et al., 2012; Feyisetan et al., 2015; Hantke et al., 2015; Harris, 2014; He et al., 2014; Ipeirotis and Gabrilovich, 2014; Kacorri et al., 2014; Kacorri et al., 2015; Katmada et al., 2016; Kurita et al., 2016; T. Y. Lee et al., 2013; Panchariya et al., 2015; Nakatsu and Iacovou, 2014; Nose and Hishiyama, 2013; Roengsamut et al., 2015; Runge et al., 2015; Saito et al., 2014; Sakamoto et al., 2016; Simperl, 2015; Stannett et al., 2013; Vasilescu et al., 2014; Yu et al., 2015	28
Environment, nature, ecological behavior	Ansari et al., 2013; Bowser et al., 2013; Fedorov et al., 2016; J. J. Lee et al., 2013; Lessel et al., 2015; Mason et al., 2012; Massung et al., 2013; Netek and Panek, 2016; Preist et al., 2014; Prestopnik and Tang, 2015; Supendi and Prihatmanto, 2015; Supriadi and Prihatmanto, 2015	12
Cartography, navigation	Bockes et al., 2015; Goncalves et al., 2014; Kawajiri et al., 2014; Martella et al., 2015; McCartney et al., 2015; Moreno et al., 2015; Reinsch et al., 2013; Simões and De Amicis, 2016; Talasila et al., 2016; Uzun et al., 2013; Wang et al., 2015; Wu and Luo, 2014	12

Language	AlRouqi and Al-Khalifa, 2014; Benjamin, 2016; Chamberlain, 2014; Itoko et al., 2014; Kobayashi et al., 2015; Packham and Suleman, 2015; Ustalov, 2015	7
Machine learning	Deng et al., 2016; Fava et al., 2015; Inaba et al., 2015; Nunzio et al., 2016; Riegler et al., 2015; Rosani et al., 2015	6
Software development	Biegel et al. 2014; LaToza et al., 2013; Snijders et al., 2014, 2015; Yakushin and Lee, 2014; Xie et al., 2015	6
Innovation	Armisen and Majchrzak, 2015; Brandtner et al., 2014; Cherinka et al., 2013; Lauto and Valentin, 2016; Roth et al., 2015	5
Health, medical, neuro-science	Bentzien et al. 2013; Dumitrache et al., 2013; Silva and Lopes, 2016; Su-sumpow et al. 2014; Tinati et al., 2016	5
Education	Roa-Valverde, 2014; Marasco et al., 2015; Sheng, 2013	3
Politics	Dos Santos et al., 2015; Mahnič, 2014; Reid, 2013	3
Work	Machnik et al., 2015; Pothineni et al., 2014; Smith and Kilty, 2014	3
Entertainment	Bainbridge, 2015; Burnett et al., 2012; Pinto and Viana, 2015	3
Finance, funding	Altmeyer et al., 2016; Sakamoto and Nakajima, 2014	2
Tourism	Y. Liu, Alexandrova, Nakajima et al., 2011; Sigala, 2015; Simões et al., 2015	3
Energy	Cao et al., 2015; Hammais et al., 2014	2
Mobility, transportation	Brito et al., 2015; De Franga et al., 2015	2
Accessibility, disability	Prandi et al., 2016, 2015	2
Fashion	Melenhorst et al., 2015	1
Marketing	Mizuyama and Miyashita, 2016	1
Physics	Sørensen et al., 2016	1
Astronomy	Greenhill et al., 2016	1
Mentoring	Nagai et al., 2014	1
Behavioral research	Cucari et al., 2016	1
Total		**110**

4.3 Empirical research papers

Of the 110 papers included in the review, 63 studies were identified as empirical research papers (Table 2). In the next sections, we report findings from the 63 empirical studies. For clarity on the two empirical results types, in the following tables, we marked the citations to studies with empirical results about the effectiveness of gamification in crowdsourcing in bold, while studies that did not directly

investigate effectiveness of gamification are not bolded. Nearly all these papers contained detailed information about the implementation of gamification in a concrete crowdsourcing system. Thus, we were able to investigate both the empirical results that allowed us to draw conclusions about the effectiveness of gamified crowdsourcing, but also the characteristics of the considered systems in the literature along the components described in Figure 3.

4.4 Characteristics of gamified crowdsourcing systems in the literature

The core of every crowdsourcing system is the work that is outsourced to the crowd. A wide variety of activities could be found in the analyzed papers. Therefore, we clustered the crowdsourced work based on the participants' core activities in several categories shown in Table 4. Most of the analyzed approaches with detailed information about the crowdsourced work try to encourage people to do computational work, which otherwise pose challenges for computers without human guidance (Von Ahn, 2009). These include the recognition of objects on images, such as animals, plant species, or waste (Carlier et al., 2016; Deng et al., 2016; Lessel et al., 2015), proofreading of text scanned with OCR technology (Kobayashi et al., 2015), relevance assessment of different images (Harris, 2014), video transcription (Saito et al., 2014), or the annotation of medical texts (Dumitrache et al., 2013). Furthermore, we found that many of the identified approaches sought to encourage people to report different kinds of location-based information. Usually, these cases are mobile apps or distributed stationary installations. Also, work that can easily be virtually disseminated in digital communities – such as the answering of user-generated questions or the provision of feedback – are popular usage cases of gamified crowdsourcing. Only a few studies considered creative creation work, such as ideation or complex optimization tasks that draw on the collective intelligence of a crowd.

Table 4. Types of Crowdsourced Work

Work type	Papers	#
Recognizing, identifying, and tagging work *image recognition, object recognition, feature recognition, character recognition, information recognition*	**Altmeyer et al., 2016**; Brenner et al., 2014; **Carlier et al., 2016**; Deng et al., 2016; **Dergousoff and Mandryk, 2015**; **Feyisetan et al., 2015**; **Itoko et al., 2014**; **Kobayashi et al., 2015**; Kurita et al., 2016; Lessel et al., 2015; Mason et al., 2012; Riegler et al., 2015; **Roengsamut et al., 2015**; Rosani et al., 2015; **Runge et al., 2015**	15
Reporting location-based information	**Bowser et al., 2013**; Brito et al., 2015; **De Franga et al., 2015**; **Goncalves et al., 2014**; **Kawajiri et al., 2014**; **Y. Liu, Alexandrova, Nakajima et al., 2011***; **Martella et al., 2015**; **Massung et al., 2013**; **Prandi et al.,**	14

location tagging, reporting of location-based information, on-location experience, taking location-based photos	**2016**; **Preist et al., 2014**; Sheng, 2013; **Simões and De Amicis, 2016**; **Talasila et al., 2016**; Uzun et al., 2013	
Answering questions/sharing knowledge *answering user-generated questions, providing feedback, knowledge-sharing in communities*	**Ipeirotis and Gabrilovich, 2014**; Inaba et al., 2015; **Y. Liu, Alexandrova, Nakajima et al., 2011***; **Machnik et al., 2015**; **Pothineni et al., 2014**; **Vasilescu et al., 2014**	6
Creative creation work *idea creation, algorithm development, requirements elicitation*	Bentzien et al., 2013; **Choi et al., 2014**; Dos Santos et al., 2015; Lauto and Valentin, 2016; **Snijders et al., 2015**; Yakushin and Lee, 2014	6
Text annotation work *text annotation, medical text annotation, biological data annotation*	Cao et al., 2015; Chamberlain, 2014; **Dumitrache et al., 2013**; **Nose and Hishiyama, 2013**; Ustalov, 2015	5
Assessment work *relationship building, relevance assessment, classification work, decision-making*	**Eickhoff et al., 2012**; Harris, 2014; **Melenhorst et al., 2015**; **Prestopnik and Tang, 2015**; Yu et al., 2015	5
Searching for and/or optimization of tasks *document searching, searching for digital profiles, finding optimal solutions*	He et al., 2014; **T. Y. Lee et al., 2013**; Nunzio et al., 2016; **Sørensen et al., 2016**; **Tinati et al., 2016**	5
Transcription work *video captioning*	**Kacorri et al.**, 2014, **2015**; **Saito et al., 2014**	3
Translation work *translating sentences*	Packham and Suleman, 2015	1
N/A *no clear work description provided, user-generated tasks, social activities*	Cucari et al., 2016; **J. J. Lee et al., 2013**; Nagai et al., 2014; Sakamoto and Nakajima, 2014	4
References in bold refer to studies in which empirical results about gamification have been reported. * Mentioned twice, because the core task of that crowdsourcing system is the answering of location-based questions.		

By analyzing the value creation (emergent or non-emergent solution) and the contribution type (homogeneous or heterogeneous contribution) according to our framework (Figure 3) and Geiger and Schader (2014), we found that most cases in the reviewed literature can be classified as gamified crowdprocessing systems (homogenous tasks, non-emergent outcome). Cases with gamified crowdsolving and crowdrating were also present. However, very few cases described gamified crowdcreating systems (see Table 5).

We identified 12 categories of gamification affordances (design elements, known from video games) in the reviewed body of literature (see Table 5). Points (in 53 cases) were clearly the most reported gamification components and usually provided the basis for other affordances. Commonly, points were combined with leaderboards (in 45 cases) to create competition between participants. Points

were also combined with further elements in diverse ways across implementations; they were used in combination with, for instance, time limits (e.g. Harris, 2014; Kacorri et al., 2014), they were used as a basis for calculating the level of crowdsourcees in a level system (e.g. T. Y. Lee et al., 2013; Saito et al., 2014), with the ability to compare them between team members and peers (e.g. T. Y. Lee et al., 2013; Saito et al., 2014), as well as with badges and missions to visualize specific goals (e.g. Bowser et al., 2013; J. J. Lee et al., 2013; Massung et al., 2013; Preist et al., 2014; Vasilescu et al., 2014).

Looking at the relative shares of affordances reported in all the reviewed papers, we found the largest variety of affordances in studies that investigated solving-related crowdsourcing work, while papers on crowdprocessing and crowdrating reported simpler forms of gamification such as simple combinations of points and leaderboards. Crowdsourcing types of crowdcreating and crowdsolving differ from crowdrating and crowdprocessing in that the participation at crowdsourcing work depends on a variety of heterogeneous contributions. Our review showed that studies in the areas of crowdcreating and crowdsolving reported the use of more manifold sets of gamification affordances. These approaches employed not only points and leaderboards, but also, for instance, storytelling, missions, and avatars. Especially crowdsourcing approaches that sought heterogeneous location-based information or sought to solve complex problems based on creative and diverse contributions often applied rich gamification designs. For instance, Tinati et al. (2016) applied points, badges, progress statistics, virtual teams, and leaderboards to engage users to find patterns in 3-D maps of neuro-scans, while Prandi et al. (2016) created an augmented reality with zombies and virtual weapons as a playground for creating a user-generated map of heterogeneous accessibility barriers.

Since most studies provided comprehensive information on the applied game mechanics and rules, we also analyzed and classified the gamification approaches along their applied goal structures (Morschheuser et al., 2017) into competitive, cooperative, and individualistic gamification designs (Table 6). Crowdsourcing types of creating and rating differ from solving and processing in that the end goal of the crowdsourced work is the emergent value from all the contributions. Therefore, it could be assumed that designers of gamified crowdsourcing systems with emergent outcomes would rather use cooperative gamification designs compared to designs of non-emergent approaches. However, when analyzing the goal structures used in these types, no notable differences could be found. Competition-

based designs with points and leaderboards that encourage individual work rather than cooperative work were used very often in all four crowdsourcing types. However, the scoring approaches differed based on how points were awarded and from which actions they could be earned. In crowdprocessing approaches, where the sheer number of contributions is often more important than quality (Geiger and Schader, 2014), users were commonly rewarded for general participation (e.g. number of completed tasks (Itoko et al., 2014), number of correct answers (Ipeirotis and Gabrilovich, 2014), or the number of visited locations (Uzun et al., 2013)). While in crowdrating approaches, where the output is more emergent, users were also rewarded for the quality of their contributions (e.g. the quality of contributions rated by others (Dumitrache et al., 2013), or similarity/agreement with other crowdsourcees' contributions (Eickhoff et al., 2012; Goncalves et al., 2014; Harris, 2014; Saito et al., 2014)). Such scoring mechanisms, which depend on the extent of agreement with other crowdsourcees' contributions, seem to be suitable for motivating users to emulate others and to "think and act like the community". In crowdsolving approaches, both forms occurred equally (e.g. the number of completed tasks (Y. Liu, Alexandrova, Nakajima et al., 2011; Yakushin and Lee, 2014), and the quality of contributions rated by others (J. J. Lee et al., 2013; Vasilescu et al., 2014)). Unfortunately, the small amount of studies investigating gamification in the crowdcreating approaches limits the identification of a clear pattern in their gamification implementations.

Table 5. Gamification Affordances per Crowdsourcing Type

Crowdsourcing type/affordances	**Processing (N = 27)**	**Rating (N = 12)**	**Solving (N = 17)**	**Creating (N = 7)**	**Frequency (total 63)**
Points/Scores	Brenner et al., 2014; **Carlier et al., 2016;** Cao et al., 2015; Cucari et al., 2016; Deng et al., 2016; **Dergousoff and Mandryk, 2015; Feyisetan et al., 2015**; **Inaba et al., 2015; Ipeirotis and Gabrilovich, 2014**; **Kawajiri et al., 2014**; **Kobayashi et al., 2015;** Kurita et al., 2016; **T. Y. Lee et al., 2013**; **Melenhorst et al., 2015; Nose and Hishiyama, 2013**; **Packham and Suleman, 2015; Prestopnik and Tang, 2015;** Riegler et al., 2015; **Roengsamut et al., 2015;** Rosani et al. 2015; **Runge**	**Altmeyer et al., 2016; Dumitrache et al., 2013**; **Eickhoff et al., 2012**; **Goncalves et al., 2014**; Harris, 2014; Kacorri et al., 2014; **Kacorri et al., 2015;** Lessel et al., 2015; Mason et al., 2012; **Massung et al., 2013**; **Preist et al., 2014**; **Saito et al., 2014**	**Choi et al., 2014**; Dos Santos et al., 2015; **De Franga et al., 2015**; He et al., 2014; Lauto and Valentin, 2016; **J. J. Lee et al., 2013**; **Y. Liu, Alexandrova, Nakajima et al., 2011**; Nunzio et al., 2016; **Simões and De Amicis, 2016**; **Sørensen et al., 2016; Tinati et al., 2016; Vasilescu et al., 2014**; Yakushin and Lee, 2014	Brito et al., 2015; **Martella et al., 2015; Pothineni et al., 2014**; **Prandi et al., 2016;** Sheng, 2013; **Snijders et al., 2015**	54

	et al., 2015; Talasila et al., 2016; Uzun et al., 2013				
Leaderboards/ Rankings	Brenner et al., 2014; Cao et al., 2015; Cucari et al., 2016; **Dergousoff and Mandryk, 2015**; **Feyisetan et al., 2015***; **Inaba et al., 2015; Ipeirotis and Gabrilovich, 2014***; **Itoko et al., 2014**; **Kawajiri et al., 2014**; **Kobayashi et al., 2015; T. Y. Lee et al., 2013***; **Machnik et al., 2015; Melenhorst et al., 2015; Packham and Suleman, 2015;** Riegler et al., 2015; Rosani et al. 2015; **Talasila et al., 2016;** Uzun et al., 2013	**Altmeyer et al., 2016;** Chamberlain, 2014; **Dumitrache et al., 2013**; **Eickhoff et al., 2012**; **Goncalves et al., 2014**; Harris, 2014; **Kacorri et al., 2015;** Lessel et al., 2015; **Massung et al., 2013**; **Preist et al., 2014**; **Saito et al., 2014**	Bentzien et al., 2013; **De Franga et al., 2015;** Dos Santos et al., 2015; He et al., 2014; Lauto and Valentin, 2016; **J. J. Lee et al., 2013**; **Y. Liu, Alexandrova, Nakajima et al., 2011**; Nunzio et al., 2016; **Tinati et al., 2016;** Ustalov, 2015; **Vasilescu et al., 2014**; Yakushin and Lee, 2014	**Bowser et al., 2013; Martella et al., 2015; Snijders et al., 2015**	45
Badges/ Achievements	Cao et al., 2015; **Feyisetan et al., 2015***; **Itoko et al., 2014**; **Kobayashi et al., 2015; T. Y. Lee et al., 2013***; **Melenhorst et al., 2015; Talasila et al., 2016;** Uzun et al., 2013	**Altmeyer et al., 2016;** Mason et al., 2012; **Massung et al., 2013**; **Preist et al., 2014**	**De Franga et al., 2015; Y. Liu, Alexandrova, Nakajima et al., 2011**; **Tinati et al., 2016; Vasilescu et al., 2014**	**Bowser et al., 2013**; **Martella et al., 2015;** Sheng, 2013	19
Levels	Brenner et al., 2014; **Feyisetan et al., 2015***; **T. Y. Lee et al., 2013*;** Riegler et al., 2015; **Roengsamut et al., 2015; Talasila et al., 2016; Yu et al., 2015**	**Dumitrache et al., 2013**; **Saito et al., 2014**	**De Franga et al., 2015;** Nagai et al., 2014; Nunzio et al., 2016; Yakushin and Lee, 2014	**Martella et al., 2015;** Sheng, 2013	15
Progress	Cao et al., 2015; **Feyisetan et al., 2015***; **Itoko et al., 2014**; **T. Y. Lee et al., 2013***		**J. J. Lee et al., 2013**; Nagai et al., 2014; **Tinati et al., 2016; Vasilescu et al., 2014**	Brito et al., 2015	9
Feedback	Brenner et al., 2014; Deng et al., 2016; **Feyisetan et al., 2015***; **Ipeirotis and Gabrilovich, 2014***; **Melenhorst et al., 2015**	**Kacorri et al., 2015**;	**J. J. Lee et al., 2013**; **Y. Liu, Alexandrova, Nakajima et al., 2011**		8
Virtual objects/ resources (e.g. weapons, materials)	**Dergousoff and Mandryk, 2015**; **Prestopnik and Tang, 2015*** ; **Talasila et al., 2016**		Lauto and Valentin, 2016; Nunzio et al., 2016; **Simões and De Amicis, 2016**	**Prandi et al., 2016*; Snijders et al., 2015**	8
Storytelling	**Nose and Hishiyama, 2013**; **Prestopnik and Tang, 2015***		Sakamoto and Nakajima, 2014; **Simões and De Amicis, 2016**	Brito et al., 2015; **Prandi et al., 2016*;** Sheng, 2013	7
Virtual territories	**Talasila et al., 2016**		**Y. Liu, Alexandrova, Nakajima et al., 2011; Simões**	Brito et al., 2015; **Martella et al., 2015; Prandi**	7

			and De Amicis, 2016	**et al., 2016*;** Sheng, 2013	
Teams		**Saito et al., 2014;** Kacorri et al., 2014; **Kacorri et al., 2015**	Bentzien et al., 2013; **Tinati et al., 2016;** Ustalov, 2015		6
Missions	Cucari et al., 2016		**J. J. Lee et al., 2013**; Sakamoto and Nakajima, 2014		3
Avatars/Virtual characters	**Dergousoff and Mandryk, 2015**; **Talasila et al., 2016**		**De Franga et al., 2015**; Nagai et al., 2014		4
References in bold refer to studies in which empirical results about gamification have been reported. * In this paper the affordance is used as experimental condition in a comparison of different gamification affordances.					

Table 6. Gamification Design Approaches per Crowdsourcing Type

Crowdsourcing type/design approach	Processing	Rating	Solving	Creating	Frequency
Competitive	16 (+2)*	9	10	3	38 (+2)
Cooperative / Intergroup competition	2	2	5	3	12
Individualistic	4 (+2)*	1	-	1	6 (+2)
Not clear (due to missing details)	3	-	2	-	5
* Two papers compared an individual with a competitive approach and found that competitions seem to be more effective.					

In most of the studies, the incentives were solely based on gamification (Table 7). Some studies additionally employed financial rewards, for instance, a small monetary task-based compensation or a prize for the leaders on a high-score list, to motivate participants.

Table 7. Incentive Orchestration

Incentive	Literature	#
Gamification	**Altmeyer et al., 2016**; Bentzien et al., 2013; **Bowser et al., 2013**; Cao et al., 2015; Chamberlain, 2014; Cucari et al., 2016; **De Franga et al., 2015**; **Dergousoff and Mandryk, 2015**; **Dumitrache et al., 2013**; **Goncalves et al., 2014**; He et al., 2014; **Itoko et al., 2014**; **Kacorri et al.**, 2014, **2015**; **Kobayashi et al., 2015**; Kurita et al., 2016; Lauto and Valentin, 2016; **J. J. Lee et al., 2013**; **T. Y. Lee et al., 2013**; Lessel et al., 2015; **Y. Liu, Alexandrova, Nakajima et al., 2011**; Martella et al., 2015; Mason et al., 2012; Nagai et al., 2014; **Nose and Hishiyama, 2013**; Nunzio et al., 2016; **Pothineni et al., 2014**; Prestopnik and Tang, 2015; Roengsamut et al., 2015; Rosani et al., 2015; **Runge et al., 2015**; **Saito et al., 2014**; Sakamoto and Nakajima, 2014; Sheng, 2013; **Simões and De Amicis, 2016**; **Snijders et al., 2015**; **Sørensen et al., 2016**; **Tinati et al., 2016**; Ustalov, 2015; Uzun et al., 2013; **Vasilescu et al., 2014**; Yakushin and Lee, 2014; Yu et al., 2015	43
Gamification + monetary rewards	Brenner et al., 2014; Brito et al., 2015; **Choi et al., 2014**; Deng et al., 2016; Dos Santos et al., 2015; Harris, 2014; Inaba et al., 2015; **Kawajiri et al., 2014; Melenhorst et al., 2015**; Riegler et al., 2015	10
Gamification + other rewards	**Machnik et al., 2015** (reward: access to specific information)	1

Both as an experimental condition	**Carlier et al., 2016**; **Eickhoff et al., 2012**; **Feyisetan et al., 2015**; **Ipeirotis and Gabrilovich, 2014**; **Massung et al., 2013**; **Packham and Suleman, 2015**; **Prandi et al., 2016; Preist et al., 2014**; **Talasila et al., 2016**	9
References in bold refer to studies in which empirical results about gamification have been reported.		

As seen in Table 8, most studies combining crowdsourcing and gamification were not targeted to any specific types of crowds but rather described implementations that are agnostic as to who the crowdsourcees should be. However, interestingly a few implementations were designed with a specific crowdsourcee segment in mind. For instance, Yakushin and Lee (2014) crowdsourced the development of algorithms for humanoid robots to a network of specialists in a competitive way, while for instance, T. Y. Lee et al. (2013) motivated employees to search for and identify Twitter accounts. These examples demonstrate that gamification is usable in a variety of usage cases with different target groups. However, to date, we have seen little research into whether there are differences between user groups or which affordances should be used to support different motivations of crowdworkers. However, first empirical studies suggest that the effectiveness of gamification may differ according to crowdsourcees' personal characteristics, such as the contributors' ages (Itoko et al., 2014; Kobayashi et al., 2015). Based on Eickhoff et al. (2012) and Itoko et al. (2014), gamification has great potential for young and senior crowdsourcees, although competition-based gamification might be more effective with young participants.

Table 8. Crowdsourcees

Participants		#
Unspecified crowd	(all other empirical papers)	44
Students	**Bowser et al., 2013**; **Kawajiri et al., 2014**; **J. J. Lee et al., 2013**; Nunzio et al., 2016; **Talasila et al., 2016**	5
Experts	Cao et al., 2015; **Dumitrache et al., 2013**; Mason et al., 2012; **Melenhorst et al., 2015**; Ustalov, 2015	5
Researchers	Yakushin and Lee, 2014	1
Employees	Lauto and Valentin, 2016; **T. Y. Lee et al., 2013**; **Machnik et al., 2015**; **Pothineni et al., 2014**; **Snijders et al., 2015**	5
The elderly	Nagai et al., 2014	1
Citizens	Dos Santos et al., 2015; **Goncalves et al., 2014**	2
References in bold refer to studies in which empirical results about gamification have been reported.		

4.5 Psychological and behavioral outcomes

Finally, we examined the psychological and behavioral outcomes described in the empirical papers and associated with the use of gamification affordances. The psychological outcomes were not commonly measured using comprehensive measurement instruments; they were mostly examined via simple questionnaires or qualitative observations, or the observations of how participants behaved was used as a proxy for psychological aspects. Currently, only four studies used validated psychometric measurement instruments (Kobayashi et al., 2015; Melenhorst et al., 2015; Prestopnik and Tang, 2015; Runge et al., 2015). Table 9 provides an overview of the literature in which results about psychological outcomes were reported.

In most studies, the behavioral outcomes of gamification are related to the participation of crowdsourcees in a specific task (Figure 3). Several studies that directly compared a gamified and non-gamified approach (Table 10) report positive outcomes, such as increases in (long-term) participation (e.g. Eickhoff et al., 2012; Kawajiri et al., 2014; T. Y. Lee et al., 2013), output quality (Eickhoff et al., 2012; Goncalves et al., 2014; T. Y. Lee et al., 2013), and reduction in cheating compared to traditional paid crowdsourcing (Eickhoff et al., 2012). However, gamification does not necessarily lead to an increase in participation. Massung et al. (2013) measured very small differences compared to a control group without gamification, while Packham and Suleman (2015) found that simple gamification approaches (points and leaderboards) cannot replace financial incentives in crowdprocessing. Overall, three studies reported more negative effects than positive (Table 10). In addition to the above studies that employed direct comparisons, 10 studies reported positive results based on users' perceptions of the gamified crowdsourcing system (Bowser et al., 2013; Dumitrache et al., 2013; J. J. Lee et al., 2013; Saito et al., 2014) or based on the measured user engagement (Pothineni et al., 2014). These – mostly descriptively reported – results showed no effects of gamification per se, but can be seen as positive indicators for the acceptance of gamification in the context of crowdsourcing (Table 10).

Some studies even compared different gamification designs and provided first empirical results for designing gamified crowdsourcing approaches in order to achieve positive psychological and behavioral outcomes (Table 10). For instance, Choi et al. (2014) showed in an experiment that explicitly expressed gamification rewards before the task phase can increase the quality of crowdsourcing work and crowdsourcees' engagement levels. The empirical findings of T. Y. Lee et al. (2013) indicate that social achievements seem to be a bit more effective than individual ones (see also Feyisetan et al., 2015; Runge et al., 2015). The authors examine this by comparing the effects of public participation rankings that encourage workers to compare their efforts with others and level systems that motivate via the visualization of individual achievements. Ipeirotis and Gabrilovich (2014) showed that the concrete design of a leaderboard or ranking can have significant effects on the participation. Based on their findings, the authors recommend to use 'all-time' leaderboards prudently, since they may demotivate low-ranked participants and newcomers. Massung et al. (2013) and Preist et al. (2014) showed demotivating effects of leaderboards and possible negative effects on the overall outcome; they propose a set of design principles for designers of gamified crowdsourcing systems and suggest mixing several motivational affordances for different target groups to increase the overall outcome. However, T. Y. Lee et al. (2013) and Dumitrache et al. (2013) indicate that adding more motivational affordances does not always increase motivation and that to date we have too little knowledge to be able to explain effectiveness of affordances for a specific user group (Itoko et al., 2014). Prestopnik and Tang (2015) highlighted the effects of storytelling in gamified crowdsourcing. By comparing two gamified crowdprocessing approaches, the researchers identified that storytelling can transform perceptions of a crowdsourcing task from work-related to play-related.

Taken together, these three categories of empirical studies on the effectiveness of gamification in crowdsourcing, more than 90% of the analyzed studies reported positive or predominantly positive outcomes of gamification in crowdsourcing (Table 10). Most cases reported positive effects on quantitative contributions (Table 11). However, qualitative and long-term effects could also be achieved, which strongly depends on the context and concrete implementation of gamification affordances.

Table 9. Psychological Outcomes Reported in the Literature

Psychological outcome	Literature	#
Motivation	**Altmeyer et al., 2016**; **Bowser et al., 2013**; **Eickhoff et al., 2012**; **Itoko et al., 2014**; **Kawajiri et al., 2014**; **Kobayashi et al., 2015**; **Y. Liu, Alexandrova, Nakajima et al., 2011**; **Machnik et al., 2015**; **Massung et al., 2013**; **Nose and Hishiyama, 2013**; **Preist et al., 2014; Prestopnik and Tang, 2015**; **Roengsamut et al., 2015**; **Runge et al., 2015**; **Tinati et al., 2016**	15
Attitudes	**Bowser et al., 2013**; **Dergousoff and Mandryk, 2015**; **Itoko et al., 2014**; **Kobayashi et al., 2015**; **Martella et al., 2015**; **Preist et al., 2014**; **Prestopnik and Tang, 2015**; **Roengsamut et al., 2015**; **Runge et al., 2015**; **Tinati et al., 2016**	10
Fun/Enjoyment	**Altmeyer et al., 2016**; **Bowser et al., 2013**; **Choi et al., 2014**; **Dumitrache et al., 2013**; **Kobayashi et al., 2015**; **J. J. Lee et al., 2013**; **Melenhorst et al., 2015; Prandi et al., 2016**; **Prestopnik and Tang, 2015**; **Roengsamut et al., 2015**; **Runge et al., 2015;** Sheng, 2013; **Tinati et al., 2016**	13
Engagement	**Altmeyer et al., 2016**; **Bowser et al., 2013; Y. Liu, Alexandrova, Nakajima et al., 2011; Snijders et al., 2015**	4
Other (e.g. appeal, interest, immersion)	Cucari et al., 2016; **Kobayashi et al., 2015**; **Melenhorst et al., 2015; Prestopnik and Tang, 2015**;	4
References in bold refer to studies in which empirical results about gamification have been reported.		

Table 10. Results on Gamified Crowdsourcing

Results	Compared a gamified approach with a non-gamified one	No comparison (interviews, user feedback, perceptions, time series analysis, influence of context factors)	Comparisons between different gamification designs	#
Quantitative -*inferential*	**Eickhoff et al., 2012**; **Nose and Hishiyama, 2013**; **Dergousoff and Mandryk, 2015**	**Melenhorst et al., 2015**	**Choi et al., 2014**; **Ipeirotis and Gabrilovich, 2014**; **T. Y. Lee et al., 2013**; **Runge et al., 2015**	8
Quantitative -*descriptive*	**Carlier et al., 2016***; **De Franga et al., 2015**; **Dumitrache et al., 2013***; **Kobayashi et al., 2015**; **Y. Liu, Alexandrova, Nakajima et al., 2011**; **Simões and De Amicis, 2016**; **Sørensen et al., 2016**; **Talasila et al., 2016**	**Pothineni et al., 2014; Roengsamut et al., 2015**	**Feyisetan et al., 2015; Packham and Suleman, 2015***	12
Qualitative	**Kacorri et al., 2015; Martella et al., 2015**	**Machnik et al., 2015; Saito et al., 2014; Tinati et al., 2016**	**Preist et al., 2014; Prestopnik and Tang, 2015**	7
Mixed -*inferential*	**Altmeyer et al., 2016; Vasilescu et al., 2014**	**Bowser et al., 2013; Itoko et al., 2014**	**Kawajiri et al., 2014**; **Massung et al., 2013**; **Prandi et al., 2016**	7
Mixed -*descriptive*	**Goncalves et al., 2014**	**J. J. Lee et al., 2013**; **Snijders et al., 2015**		3
Total	**More positive (14) / negative (2)**	**More positive (10)**	**More positive (10) / negative (1)**	**37**
* Studies that reported negative effects of gamification, for instance compared to paid crowdsourcing or non-gamified approaches				

Table 11. Positive Effects of Gamification in Crowdsourcing Reported in the Literature

Outcomes	Literature	#

Positive effects on the quantitative contribution / willingness to contribute	**Altmeyer et al., 2016; Bowser et al., 2013; De Franga et al., 2015**; **Dergousoff and Mandryk, 2015**; **Eickhoff et al., 2012; Feyisetan et al., 2015; Ipeirotis and Gabrilovich, 2014**; **Itoko et al., 2014; Kawajiri et al., 2014; Kobayashi et al., 2015; J. J. Lee et al., 2013; T. Y. Lee et al., 2013; Y. Liu, Alexandrova, Nakajima et al., 2011; Martella et al., 2015; Massung et al., 2013**; **Nose and Hishiyama, 2013; Pothineni et al., 2014; Prandi et al., 2016; Preist et al., 2014; Prestopnik and Tang, 2015; Roengsamut et al., 2015; Simões and De Amicis, 2016**; **Snijders et al., 2015; Talasila et al., 2016; Tinati et al., 2016; Vasilescu et al., 2014**	26
Positive effects on the qualitative contribution	**Dergousoff and Mandryk, 2015**; **Eickhoff et al., 2012; Feyisetan et al., 2015; Goncalves et al., 2014; Ipeirotis and Gabrilovich, 2014**; **Kawajiri et al., 2014; Kobayashi et al., 2015; T. Y. Lee et al., 2013; Massung et al., 2013**; **Prestopnik and Tang, 2015; Runge et al., 2015; Simões and De Amicis, 2016; Sørensen et al., 2016**	13
Positive effects on continued work / long-term engagement	**Itoko et al., 2014; Kawajiri et al., 2014; Kobayashi et al., 2015; T. Y. Lee et al., 2013; Massung et al., 2013**; **Prestopnik and Tang, 2015**	6

5 DISCUSSION

In this study, we have provided a comprehensive review and overview of the use of gamification in crowdsourcing in the current body of literature. Following an integrated conceptual framework (Figure 3), we analyzed characteristic features of gamified crowdsourcing systems. Especially, we reviewed the use of different forms of gamification in different types of crowdsourcing (crowdprocessing, crowdsolving, crowdrating, and crowdcreating), as well as the interplay between gamification and additional monetary rewards, the types of work that have been crowdsourced, the types of crowdsourcees, and the domains in which gamification in crowdsourcing has been applied. Furthermore, we investigated the results of empirical studies on the psychological and behavioral outcomes of gamification in crowdsourcing systems. This meticulous mapping enabled us to discuss recommendations for designing gamified crowdsourcing systems as well as limitations, emerging issues, and future research directions.

5.1 Recommendations for designing gamified crowdsourcing systems

We form recommendations by triangulating from the results in the body of the reviewed literature and the results of this review. One of the overall primary findings of our review is that gamification positively affects crowdsourcing work, either in the form of increased crowdsourcee motivations or contributions. Thus, it is less important to investigate whether gamification works as a whole; instead, we need to delve deeper to explore which specific design choices are successful in the various crowdsourcing types.

The reviewed literature indicates that gamified crowdsourcing systems that process homogeneous, easily enumerable tasks, such as in crowdrating or crowdprocessing, most commonly implement simple points-based and leaderboard-based game designs (Table 5). Generally, these homogeneous tasks are simple, repetitive, and are quick to complete. Therefore, using rich game designs, such as full-fledged games, could be redundant and excessive (T. Y. Lee et al., 2013; Dumitrache et al., 2013). Empirical studies (Table 10) found that the use of simple gamification approaches is efficient and therefore cost-effective for crowdrating or crowdprocessing tasks (e.g. Eickhoff et al., 2012; Feyisetan et al., 2015). On the other hand, our review indicates that studies in the contexts of crowdsolving and crowdcreating made more manifold uses of affordances. Since such heterogeneous tasks commonly vary in complexity and require a wide spectrum of skills sets, manifold gamification designs that provide the opportunity to engage broad target groups in the short and/or long term might be helpful. Therefore, we recommend considering task characteristics and especially the task complexity when designing gamification approaches for crowdsourcing systems.

Our overview indicates that points and leaderboards are the most used gamification affordances (Table 5). However, the differences are in the details. Points, which are the core of most gamification designs, have been implemented in different forms across all four crowdsourcing types. In crowdprossessing approaches, points are commonly given as a reward for the quantity of fulfilled tasks. Crowdsolving and crowdrating approaches use scoring mechanisms that reward the quality or quantity of a contribution or a combination of both. Points are simple, flexible, and very malleable, and as can often be extended via the introduction of further gamification affordances on top of them. For instance, studies of crowdprocessing and crowdrating often apply time pressure (Eickhoff et al., 2012; Harris, 2014; Kacorri et al., 2014) or leaderboards (Ipeirotis and Gabrilovich, 2014; Runge et al., 2015) to create (self- or other-)competitive engagement. On the other hand, crowdcreating may benefit from mechanisms that reward cooperative and collaborative behavior. Several examples use rich gamification designs with a diverse set of affordances (see Table 5). Massung et al. (2013) and Preist et al. (2014) propose mixing several motivational affordances for different target groups to increase the overall outcome. On the other hand, the experiment by T. Y. Lee et al. (2013) indicates that adding more motivational affordances in a crowdprocessing case does not always increase motivation. These examples

show that many different facets, such as context-specific and task-specific constraints, target group characteristics, or a specific goal behavior and outcome may influence the gamification design. Although points (especially points that reward quantitative participation) and leaderboards are the most commonly implemented gamification affordances, we recommend not implementing these elements too hastily. Rather, we recommend considering the results of extant empirical studies, which has been presented in this review (Table 10), and theoretical frameworks on the design of game mechanics for crowdsourcing work (Von Ahn 2008), in order to incentivize right activities in the right form.

Since there have only been a few studies on gamification in crowdcreating systems, reliable recommendations are more difficult to provide directly based on results alone. However, as designers of crowdcreating systems are typically seeking to gather comprehensive artifacts based on heterogeneous contributions, implementing gamification in various forms that is able to engage broad and heterogeneous target groups should be considered, instead of, for instance, merely points and badges. The crowdcreating approach requires crowdsourcees to undertake creative tasks. Therefore, too narrowly defined goals may reduce creativity and thus the output of the work. Further, promoting cooperation or a combination of cooperation and competition, rather than competition alone, could potentially be beneficial for reaching a shared output or goal (Tauer and Harackiewicz, 2004). Studies on similar areas have for instance found that crowdsourcing systems with emergent outcomes can benefit from collaborative features (Blohm et al., 2010) and that strong cooperation can positively affect the outcome of crowdsourced ideation (Bullinger et al., 2010). Thus, we recommend implementing cooperative gamification approaches (Morschheuser et al., 2017) and affordances such as virtual teams and shared goals that might promote cooperative behaviors. We also encourage practitioners who seek to employ crowdcreating to experiment with a variety of gamification designs in order to identify an effective fit of design choices.

Empirical findings indicate that leaderboards/rankings seem to be very effective in motivating certain crowdsourcing community users to increase their level of contribution (T. Y. Lee et al., 2013). However, several studies show that the concrete design of a leaderboard affects participation (cf. in the context of *crowdprocessing* (Ipeirotis and Gabrilovich, 2014; T. Y. Lee et al., 2013) and *crowdrating*

(Massung et al., 2013; Preist et al., 2014)). Based on these findings, short-term leaderboards are recommended (Ipeirotis and Gabrilovich 2014), because 'all-time' leaderboards can demotivate low-ranked participants and novices, for whom reaching the top will seem impossible. Studies by Massung et al. (2013) and Preist et al. (2014) showed that long-term leaderboards can lead to demotivation and can have possible negative effects on the overall outcome of the crowdsourcing (Straub et al., 2015). The design of a leaderboard implementation seems, therefore, highly context-dependent. However, Kobayashi et al. (2015), T. Y. Lee et al. (2013), and Tinati et al. (2016) note that many crowdsourcing approaches follow the '90-9-1' participation rule, implying that only 1% of the users perform almost all of the actions, and consequently, long-term leaderboards that motivate the 1% might therefore also be suitable for some crowdsourcing implementations. In contrast to rankings that generally encourage workers to compare their efforts with others, level systems could be used that motivate by visualizing individual achievements. Empirical findings of T. Y. Lee et al. (2013) indicate that differences might exist between these two types of gamification. The results highlight that social achievements seem to be slightly more effective than individual-level systems. Thus, affordances with social factors such as rankings or public visualizations of individual achievements, should be preferred if the context allows the use of such motivational affordances.

Very few studies have considered the moderating effects of personal factors of crowdsourcees. Itoko et al. (2014) showed that while gamification generally does work for a wide spectrum of age groups, competition-based gamification might be more effective for young rather than older participants. Further, Koivisto and Hamari (2014) find that social factors and cooperation are generally more important aspects for females in gamification. Several studies (Ipeirotis and Gabrilovich, 2014; Itoko et al., 2014; T. Y. Lee et al., 2013; Massung et al., 2013) indicate that for instance altruism may explain personal differences in cooperative behavior, while for instance curiosity may make users more interested in the novel nature of gamification. Moreover, gamification-related literature suggests that users can have very different approaches towards games and how they interact with them. For instance, some users may be more motivated by seeking to reach achievements, and others by immersion-related designs (Ermi and Mäyrä, 2005; Hamari and Tuunanen, 2014; Yee, 2006). Thus, sustainable gamification designs should also consider personal factors as well as orientation to work and games.

Finally, Table 7 shows that, in some cases, gamified crowdsourcing systems use a combination of gamification and financial incentives. Considering how gamification is implemented in crowdsourcing (see Table 5), it appears that monetary rewards have been used in implementations that employ simpler gamification designs, mainly in combination with points and leaderboards. Although studies suggest that extrinsic rewards (such as money) can potentially decrease intrinsic motivation (Deci, 1971; Deci et al., 1999), Massung et al. (2013) and Preist et al. (2014) found in their experiment that gamification in combination with financial rewards can in fact increase participation when compared to gamification alone. However, the authors investigated this phenomenon only in a short-term scenario and indicated that financial rewards, in comparison to gamification, may reduce participation in the long term. Further, Ipeirotis and Gabrilovich (2014) indicate that the output quality of paid crowdsourcing can be worse, since payments might wipe out intrinsic motivation to accomplish tasks with high quality. Therefore, monetary incentives should be implemented cautiously in combination with gamification.

5.2 Limitations, emerging issues, and future research directions

Our results provided a structured overview that helps to identify current issues and gaps for future research. We addressed this by providing a research agenda that covers methodological, theoretical, and thematic directions for future research, as well as by pinpointing empirical and design research gaps.

5.2.1 Methodological agenda

Although 37 of the reviewed studies contained empirical findings on the effects of gamification in crowdsourcing and our analyses show that while gamification is a viable and beneficial approach for motivating crowdsourcees, our understanding of how different affordances affect motivational and behavioral outcomes in crowdsourcing is still in its infancy. A common methodological issue in the current body of literature is that very few studies have used properly validated psychometric measurement instruments when gauging changes in crowdsourcees' motivations. Due to this methodological shortcoming, the individual effects of gamification affordances on psychological and behavioral outcomes are comparable only on an abstract level. Moreover, many empirical studies reported only descriptive statistics (Table 10), while several studies did not isolate and measure separately the effects of different

gamification mechanics. Consequently, current research provides scattered, particular insights regarding the complex interaction of all factors that affect crowdsourcees' motivations in gamified crowdsourcing systems. Thus, we call for careful and systematic empirical mapping of the effects of affordances, psychological outcomes, and behavioral outcomes, as well as the differences between various gamification designs.

Agenda point 1: *Further studies should isolate gamification effects by using isolated experiment groups for different gamification affordances, to survey psychological outcomes with validated measurements, and to apply statistical methods that go beyond the description of data.*

Most of the reviewed empirical literature only examined the effects of gamification in crowdsourcing in a short timeframe (< 4 weeks). Likewise, many empirical findings relied on a small sample size (N < 40). The reasons might lie in the novelty of the phenomenon and the fact that many studies investigated the effectiveness of prototypes or concepts (e.g. Nagai et al., 2014; Preist et al., 2014; Massung et al., 2013; Saito et al., 2014). Very few researchers applied experimental designs that were able to control the influences of novelty effects (e.g. Kawajiri et al., 2014), which are deemed a characteristic of many gamification approaches (Koivisto and Hamari 2014). While small studies can provide quick insights into the phenomenon, additional large longitudinal studies are needed to ensure the reliability and generalizability of the results. Furthermore, long-term studies could identify and control for the influences of novelty or saturation effects (cf. T. Y. Lee et al., 2013), which have seen little attention in the current literature.

Agenda point 2: *Future research should include larger sample sizes and should conduct longitudinal studies to provide rigorous and generalizable results that extend the current literature.*

Most of the reviewed literature with empirical results reported quantitative results (Table 10). Since gamification is deeply rooted in psychology, we need qualitative research that goes beyond the measurement of simple perceptions if we are to understand mechanisms and triggers that evoke engagement and motivation in gamified crowdsourcing (e.g. Massung et al., 2013; Preist et al., 2014; Prestopnik and Tang, 2015). Qualitative findings may also be able to inform quantitative research into the

antecedents of participation intentions. However, currently, most of the interview-based studies were very superficial and provide few deep insights into the manifold ways in which crowdsourcees perceive gamification and its effects on their work. Furthermore, most existing qualitative studies provide mainly findings from people who participated in gamified crowdsourcing and therefore have positive feelings towards the overall topic. However, knowledge of the reasons why people stop participating in gamified crowdsourcing and the perceptions of users who are critical towards participating could help one to design more successful gamified crowdsourcing systems. As the current literature has mainly reported positive results, some publication bias may loom in the body of literature.

Agenda point 3: *Future qualitative research in gamified crowdsourcing should seek to capture all different facets of the phenomenon. Qualitative research should provide in-depth results that cover not only the positive perceptions, but also the reasons why people stop participating.*

Our review identified only very few studies considering the influence of user characteristics (Eickhoff et al., 2012; Itoko et al., 2014). However, previous research suggests that the perceptions towards and effectiveness of a gamification approach strongly depends on users, their characteristics, and their individual goals (Hamari, 2013, Kobayashi et al., 2015, Koivisto and Hamari, 2014). The impacts of personal characteristics and player types (Hamari and Tuunanen, 2014) as moderators of psychological and behavioral effects as well as the differences between various types of crowdsourcees (e.g. students, employees, or citizens) (Table 8) require further scrutiny. In this context, differences between the so-called *power contributors* and *free-riders* could also provide new insights into the design of effective gamified crowdsourcing systems for different target groups (T. Y. Lee et al., 2013; Levina and Arriaga, 2014; Zhao and Zhu, 2014a).

Agenda point 4: *Future research should systematically investigate differences between different types of crowdsourcees, and should consider including the potential influences of user characteristics as a moderator in research models on the effectiveness of gamified crowdsourcing.*

5.2.2 Theoretical agenda

Most of the reviewed studies with empirical results on gamification in crowdsourcing focused on the effectiveness of gamification. Most of these studies lacked theory to ground the research, were rudimentary, or were disconnected from the applied work. By paying attention to these theoretical limitations, future research could provide valuable contributions to better understand and explain gamification in crowdsourcing. We recommend borrowing theoretical perspectives (Whetten, 1989) from psychology, philosophy, or marketing to serve as a basis for study design and to explain psychological effects and behavioral outcomes. Especially, we recommend drawing on Csíkszentmihályi's (1990) theory of flow and self-determination theory (Ryan and Deci, 2000), when investigating the motivational effects of gamification affordances. These two theoretical perspectives are frequently used to investigate motivational effects in crowdsourcing (Zhao and Zhu, 2014b; Zheng et al., 2011) and gamification (Hamari and Koivisto, 2014; Hamari et al., 2016), since they provide insights into inducing and achieving intrinsic motivation. Considering gamification elements as motivational affordances (Huotari and Hamari 2016) that are designed to stimulate motivational needs, goals achievement, and help people to achieve their personal goals, goal-setting theory and the affordance concept provide essential foundations (cf. Huotari and Hamari, 2016; Jung et al., 2010; Morschheuser et al., 2017). Finally, to understand the effects of gamification and gamification rewards on attitudes and behavioral outcomes, we recommend that researchers draw on the theory of planned behavior (Ajzen, 1991) and self-efficacy theory (Bandura, 1977), which are often applied in general gamification research (Hamari and Koivisto, 2015a, 2015b).

Agenda point 5: *Future research should increasingly employ theory from (motivational) psychology to justify research activities, operationalize research, and interpret results.*

5.2.3 Thematic agenda

Previous research on the motivation of crowdsourcees has primarily analyzed motivations in non-gamified crowdsourcing platforms with financial incentives. Commonly, the findings have indicated that users are driven by a mixture of intrinsic motivation and monetary rewards (Brabham, 2010, 2008b;

Kaufmann et al., 2011; Leimeister et al., 2009; Zhao and Zhu, 2014a; Zheng et al., 2011). Our overview demonstrated that 68% of the analyzed gamified crowdsourcing cases used only gamification to incentivize crowdworkers (Table 7). This indicated that gamification could not only be used in addition to financial rewards to increase positive experiences (e.g. engagement or enjoyment); rather, it provides a cost-effective opportunity to entirely replace financial incentives. Some studies demonstrated the complex interplays between financial and gamified incentive structures (Massung et al., 2013; Preist et al., 2014). To date, it is unclear for which crowdsourcing system type, crowdsourcee type, and task type the use of gamification is more beneficial compared to financial incentives, or when the combination of the two is the best approach. Future research should compare different incentive mechanisms (see Straub et al., 2015; Harris et al., 2015) and should consider contextual factors and user characteristics. Furthermore, the economic value of gamification also requires further research. Future research could examine the development costs in relation to the effects of gamification, to evaluate the value and to provide insights into gamification-based business models.

Agenda point 6: *Research into gamified crowdsourcing should explore optimal incentive orchestrations for different crowdsourcing contexts and should provide insights into the overall cost efficiency of gamified crowdsourcing.*

The findings summarized in Table 6 demonstrate that cooperative approaches, such as gamified crowdcreating systems, are currently receiving less attention from scholars compared to the other system types. This is surprising, since several popular crowdcreating examples, such as Google Ingress, Dell's Ideastorm, or Threadless (Kavaliova et al., 2016) have implemented various gamification approaches. Further, notably, all reviewed empirical studies that have measured the effects of gamification on participation have analyzed the effects on the intention of an individual to participate, but have neglected that crowdsourcees can form groups with collective intentions (Tsai and Bagozzi, 2014). Studies have shown that collective intentions play a key role in cooperative crowdsourcing (A. X. L. Shen et al., 2009; X.-L. Shen et al., 2014). Finally, we identified that social factors, which have been identified as an essential aspect of gamification (Hamari and Koivisto, 2015a) and could gauge cooperation (such as trust, reciprocity, and sense of community), have been neglected in the literature.

Future research that continues ideas from previous studies about virtual teams (Jarvenpaa and Leidner, 1998; Powell et al., 2004), collective intentions in virtual communities (Tsai and Bagozzi, 2014), cooperative games design (Morschheuser et al., 2017), and social factors of gamification (Hamari and Koivisto, 2015b) could provide new insights into the effects of gamification on collective intentions, relationships between crowdworkers, social identities, or collaborative behavior. Future research could utilize established social psychological theories that have evaluated the effects of competition, cooperation, and the combination of the two on enjoyment or performance as a basis for examining the motivational effects of different goal structures in gamification approaches (Tauer and Harackiewicz, 2004; Morschheuser et al., 2017). In this context, the use of cooperative gamification approaches such as virtual teams, cooperative missions, or shared goals that empower the formation of groups and collective intentions could be analyzed to expand the mainly competition-focused gamification conceptions and that help to design effective gamified crowdsourcing communities.

Agenda point 7: *Future research should seek to investigate the design and effects of cooperative gamification and consider social factors in crowd communities.*

Crowdsourcing as a problem-solving concept is a multifaceted phenomenon and can be applied in various contexts. Marginal differences can be found in the reviewed studies regarding the domain in which the systems are applied (Table 3), the crowd characteristics (Table 4, Table 8), and the media (e.g. mobile apps (Bowser et al., 2013; Uzun et al., 2013), website (Choi et al., 2014; T. Y. Lee et al., 2013; Y. Liu, Alexandrova, Nakajima et al., 2011), or local installations (Goncalves et al., 2014)). Future research is needed to understand how contextual factors affect gamified crowdsourcing systems. Optimally, studies could apply one gamified crowdsourcing system in a variety of contexts. Since this would be a rather sizeable undertaking, we might have to wait for the accumulating literature to cover more ground.

Agenda point 8: *Research is needed to understand how contextual factors, such as the domain, the media, and crowd characteristics affect gamified crowdsourcing systems.*

Our overview indicated that gamification implementations differ in the context of crowdsolving, crowdrating, and crowdprocessing approaches (Table 5). Finally, we identified different recommendations for designers of gamified crowdsourcing systems. Further work is needed to evaluate and extend these recommendations and to study the potentials of different design approaches. Especially manifold designs with for instance avatars, storytelling, or virtual teams provide opportunities for future research.

Furthermore, advanced gamification approaches that automatically consider user characteristics and context characteristics should be examined. Building on the results of Itoko et al. (2014) and Koivisto and Hamari (2014), individual adaptive incentive orchestrations might increase effectiveness, acceptance, and long-term motivations. Such adaptive gamification design that goes beyond the current rewards mechanisms used in gamification could utilize recent developments of individualization in crowdsourcing (Geiger and Schader, 2014) and games design (Prakash et al., 2009). Finally, recent technology trends such as virtual realities (Prandi et al., 2016), connected everything, artificial intelligence, and sharing economies are influencing current developments in game design and crowdsourcing. These trends also provide new spaces for gamified crowdsourcing systems that should be studied.

Agenda point 9: *Future research should expand the design space used in current gamified crowdsourcing systems and should consider novel trends in games design and crowdsourcing.*

5.2.4 Future research

In this review of applied research and theoretical papers, we were particularly interested in the use of gamification in crowdsourcing systems. However, it is possible that related research has been conducted, also under other conceptual developments such as serious games, games-with-a-purpose, pervasive games, human-based computation, or persuasive technology. Some of these related research areas might be investigating similar phenomena, but were not included in this study. Therefore, future efforts could compare these approaches and their contributions to gamified crowdsourcing. Relatedly, we conducted the literature searches intentionally with a set of keywords to find particularly studies on gamification and crowdsourcing. In our view, our selection of search keywords and data sources was successful for the review's intended breadth. The choice of a systematic literature study is the reason

for some of these limitations (Boell and Cecez-Kecmanovic, 2015). However, in our view, the benefits of a structured summary and a clear aggregation of previous findings outweighed the disadvantages in our case. Future efforts could go beyond these limitations and could extend our findings.

6 CONCLUSIONS

Along with the emergence of the interwoven phenomena of gamification and crowdsourcing, gamified crowdsourcing systems have drawn scientific attention and have led to a continuously rising number of research publications. In this review, we sought to provide a comprehensive conceptualization and a structured overview that compared the different characteristics of gamified crowdsourcing systems, examined the results on the effectiveness of gamification in crowdsourcing, and highlighted starting points for future research. We found a wide array of different gamification implementations in different types of crowdsourcing in the literature. However, the literature seems to be unanimous; gamification does seem to work with a majority of configurations and can positively affect the motivations of crowdsourcees, their participation, and output quality. Depending on the type of crowdsourcing (crowdcreating, crowdsolving, crowdprocessing, and crowdrating), we identified patterns in the use of gamification affordances. In the context of crowdsourcing initiatives that provide homogenous and often more monotonous tasks such as crowdprocessing and crowdrating, authors commonly report the use of simple forms of gamification such as points and leaderboards (Table 5). Conversely, crowdsourcing studies with crowdcreating and crowdsolving work that seek diverse and creative contributions employ gamification in more manifold ways with a richer set of mechanics. Generally, gamification is used to promote a kind of competition between the participants rather than a collaborative experience. Monetary rewards could be used as an addition in gamified crowdsourcing systems, but most of the analyzed cases did not apply supplementary financial incentives. However, at this early stage, the literature is still fairly fragmented, and too little research has been conducted to draw clear conclusions on which specific implementations would work better or worse in certain situations. It is clear that contextual factors and factors related to crowdsourcees play a role, but to what extents and how are still unclear. These and further aspects that would help us to understand and design successful gamified crowdsourcing systems provide much room for future research.

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