

STATE OF PLAY: A CITATION NETWORK ANALYSIS OF HEALTHCARE GAMIFICATION STUDIES

Research paper

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Abstract

Researchers and practitioners alike increasingly recognize gamification as a potential tool to evoke desired behaviours in patients, healthcare professionals, and healthy end-users aiming to live a healthier lifestyle. Thus, the number of scientific publications in healthcare gamification is rapidly increasing and due to the interdisciplinary nature of the research field, knowledge about this topic is being scattered over many research communities. Building on a large number of articles on healthcare gamification and utilizing citation network analysis, this study sheds further light on the extant knowledge on healthcare gamification. Based on our approach, we were able to (1) evaluate essential articles and authors covering the topic, (2) analyse the recent development of research on healthcare gamification, and (3) identify past research foci and knowledge gaps in our knowledge on healthcare gamification. By doing so, we call for further research on healthcare gamification and provide researchers with potential avenues for future research projects.

Keywords: Gamification, Healthcare, Literature Review, Citation Network Analysis, Social Network Analysis.

1 Introduction

Gamification is a recent trend in practice and research that aims at utilizing people's passion for videogames as well as modern and pervasive information technologies to evoke inherent motivation for non-gaming applications such as repetitive and tiresome everyday tasks (e.g., taking medication every day) (Dithmer et al., 2016, Maturo and Setiffi, 2016). Within research, two prevailing views on gamification exist. Deterding et al. (2011) define gamification as "the use of game design elements in non-game contexts", whereas Huotari and Hamari (2012) understand gamification as a process of enhancing services with affordances to create gameful experiences. Despite their differences, both views share a central understanding of gamification as a means to change people's behaviour and reinforce desired behavioural traits (Deterding et al., 2011, Spil et al., 2017). Gamification has attained widespread recognition by practitioners and researchers from various domains including education, finance, workplace settings, and healthcare (Thiebes et al., 2014). Especially in healthcare, gamification is increasingly being recognized as a potential tool to evoke desired behaviours in patients, healthcare professionals, and healthy end-users aiming to live a healthier lifestyle (Sardi et al., 2017, Schmidt-Kraepelin et al., 2018). Gamification in healthcare is, for example, used to increase people's motivation to be physically active (Hamari and Koivisto, 2015) or to eat healthier (Jones et al., 2014a, Jones et al., 2014b), to support people with chronic diseases in managing their disease (Elias et al., 2013), to help people with mental disorders to overcome their disorders (Brown et al., 2016), or to promote the usage of e-learning systems among medical students (Nevin et al., 2014). In addition, successful examples such as Virgin Pulse and Discovery Vitality as well as recent market reports (e.g., Research N Reports (2018)) indicate the huge economic potential of gamification in healthcare.

Due to healthcare gamification being a relatively young and inherently interdisciplinary stream of research, the number of scientific publications in this research area is rapidly increasing. Adding to this, the interdisciplinary nature of research on healthcare gamification results in knowledge about this topic being scattered over many different scientific outlets, conference proceedings, and research communities. Several literature review studies already exist that have aimed to consolidate and structure this steadily growing and scattered body of knowledge on gamification in general (e.g., Hamari et al., 2014, Seaborn and Fels, 2015) and healthcare gamification in particular (e.g., Alahäivälä and Oinas-Kukkonen, 2016, Sardi et al., 2017). However, the fast pace and scattered nature of this research stream, which makes it difficult for researchers to identify and assess this large body of literature in its entirety manually, has led to the emergence of a series of rather narrowly focused literature reviews (see section two). Extant research indicates that these literature reviews based on subjective analysis might be constrained by the authors' limited time, energy, cognitive capacity, and personal perspectives (Liang et al., 2016). In addition, it is possible that important papers have been omitted or misinterpreted due to the authors' research interests (Liang et al., 2016). Considering the growing number of published literature reviews on healthcare gamification, we are convinced that there is an urgent need to consolidate our extant knowledge about this topic in a more comprehensive and holistic manner. We thus ask the following two research questions:

RQ1: How did the body of knowledge on healthcare gamification recently evolve?

RQ2: What were the primary research foci of past research on healthcare gamification and what research gaps exist?

To answer our research questions, we employ a three-staged literature review research design that was oriented towards Schmidt et al. (2015), whereby we first conduct a structured literature review, followed by a citation network analysis, and a concept-centric content analysis of identified studies on healthcare gamification. The contribution of our work is three-fold. First, based on the analysis of our citation network graph, which consisted of more than 2,400 articles, we identified central articles and authors for healthcare gamification and were able to analyse the flow of knowledge within this literature stream. Second, our content analysis enabled us to reveal key contexts, research foci, and important gaps in our current knowledge on healthcare gamification. Thus, our results provide researchers interested in healthcare gamification with a structured assessment of the current body of

knowledge in this area and a research agenda that highlights potential avenues for future research. Third, by applying social network analysis (SNA) techniques, our work also creates awareness of innovative forms of literature reviews which has been demanded in literature (Fleming et al. (2014)).

The remainder of the paper is structured as follows. Section two offers a brief overview of extant literature reviews on gamification in general and gamification in healthcare. In section three, we provide an overview of our chosen research approach and details about each step of identifying relevant literature and manual content analysis. Section four represents the main section of this paper and highlights the results of our literature review. In sections five, we discuss the results of our literature review, limitations of our research, and potentials for further research. We conclude our paper in section six.

2 Extant Literature Reviews on Healthcare Gamification

Gamification is a relatively new and scattered field of research that comprises publications from various research domains. Consequently, researchers have recently sought to consolidate the vast body of knowledge in this area by publishing several literature reviews on gamification. Table 1 provides a list of available literature reviews on gamification in general (2) and healthcare gamification in particular (6) in comparison to this literature review.

Review	No. of Articles	Applied Method	Analysis Focus
Hamari et al. (2014)	24	Meta-Analysis	Empirical findings on implemented motivational affordances and related psychological and behavioural outcomes in gamified systems. Not restricted to the health context.
Seaborn and Fels (2015)	42	Meta-Analysis	Applied and evaluated examples of gamification + conceptual work. Not restricted to the health context.
Theng et al. (2015)	10	Meta-Analysis	The use of games, gamification, and virtual environments for diabetes self-management.
Alahäivälä and Oinas-Kukkonen (2016)	15	Meta-Analysis	Persuasion contexts of gamified health behaviour support systems.
Lewis et al. (2016)	18	Meta-Analysis	The use of reward systems in health-related gamified interventions.
Johnson et al. (2016)	19	Meta-Analysis	Empirical findings on the effectiveness and quality of health and well-being gamification applications.
Matallaoui et al. (2017)	25	Meta-Analysis	Empirical Findings on gamified systems and serious games for exercising. Review of deployed motivational affordances and the effectiveness of gamification features in exergames.
Sardi et al. (2017)	46	Meta-Analysis	Benefits and pitfalls of employed gamification strategies and serious games in e-Health.
This review	2,457	Citation Network Analysis	Recent developments of research on healthcare gamification, past research foci, and knowledge gaps.

Table 1. Overview of literature reviews on (healthcare) gamification.

Literature reviews relevant for this research can be broadly classified into general gamification reviews and reviews focused on healthcare gamification. To this end, past literature reviews on gamification in general have investigated empirical confirmations of the behavioural effects of gamification (e.g., Hamari et al., 2014) as well as applications and conceptualizations of gamification (e.g., Seaborn and Fels, 2015). Past literature reviews on healthcare gamification on the other hand have looked at empirical studies in specific but different healthcare contexts such as physical exercise, well-

being, or self-management of chronic diseases (e.g., Johnson et al., 2016, Matallaoui et al., 2017, Theng et al., 2015), the different persuasion contexts of health behaviour support systems (e.g., Alahäivälä and Oinas-Kukkonen, 2016), the use of reward systems in gamified healthcare interventions (e.g., Lewis et al., 2016), and investigated the benefits and pitfalls of gamification strategies employed in healthcare (e.g., Sardi et al., 2017). They identified the absence of research on the long-term or sustained effects of gamified applications, and small sample sizes as main gaps in extant literature. Although past literature reviews offer important and valuable insights into gamification in healthcare, they either only investigate empirical studies, are limited to very specific contexts or do not clearly differentiate between gamification and related concepts such as serious games (e.g., Sardi et al., 2017, Theng et al., 2015). To this end, we are not aware of any literature review available that has aimed at analysing, explaining, and organizing the existing publications in a comprehensive and holistic manner. We attribute this to the inherent interdisciplinary nature and resulting scattered nature of the existing scientific landscape in this area. To cover this gap in our knowledge, we focus our analysis on literature about healthcare gamification covering both prior empirical and conceptual studies. This approach is especially important for evaluating our current level of knowledge and identifying knowledge gaps as well as future research directions. In addition, we contribute to the knowledge on healthcare gamification by conducting citation network analysis, which enables us to identify the most influential publications and research sub-streams in healthcare gamification.

3 Research Design

For our literature review, we employ a three-staged research design that was informed by Schmidt et al. (2015). After conducting a structured literature review to construct our baseline set of relevant literature (stage 1), we set up the initial citation network graph and use relevant node attributes such as out-degree (the number of tail ends adjacent to a node) and closeness centrality (the sum of the length of the shortest paths between a node and all other nodes in the graph) as well as SNA methods (i.e., main path analysis and k-core graphs) to analyse our citation network (stage 2). Finally, we performed a manual concept-centric literature analysis focussing on the identification of main contexts of gamification in healthcare as well as past research foci and potential future research opportunities with respect to these contexts (stage 3). Figure 1 provides of our three-staged research approach.

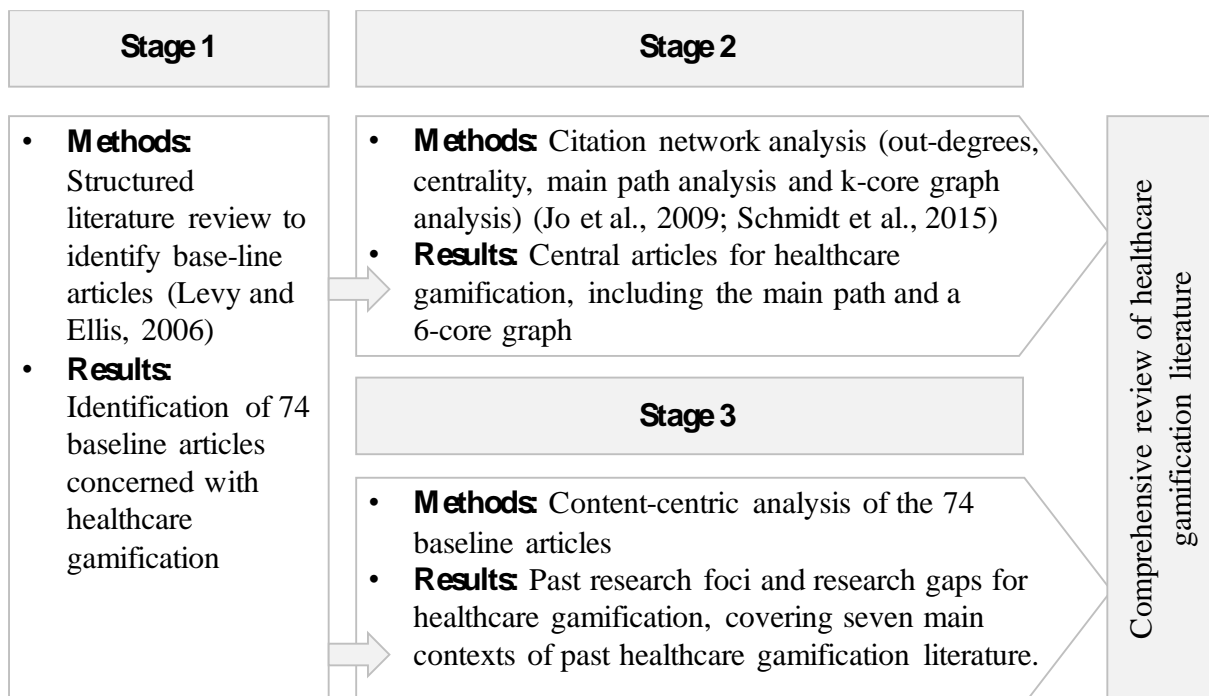


Figure 1. Research approach.

3.1 Structured Literature Review to Identify Baseline Articles

As our overall research design was informed by Schmidt et al. (2015), we started building the foundation for our citation network by conducting a structured literature review following the guidelines of Levy and Ellis (2006). We therefore searched the scientific literature databases IEEEExplore, EBSCO Host, ACM Digital Library, Science Direct, PubMed, ProQuest, and AISel using the search string: *TITLE-ABSTR-KEY(Gamif*) and TITLE-ABSTR-KEY(health* OR medic* OR exer* OR life* OR therap* OR fitness OR patient OR wellness)*.

The databases were chosen to cover a wide range of journals and conferences in the areas of computer science, life sciences, medical informatics, and information systems. Where possible, our search was limited to peer-reviewed publications published in 2009 or later, since gamification only gained widespread recognition by researchers and practitioners in 2009. The database search yielded a total of 459 publications, including duplicates. After removing duplicates, 409 publications remained for further relevance screenings. Two researchers separately assess the relevance of each article by screening title, abstract, and keywords against predefined inclusion and exclusion criteria. We excluded articles that were not peer-reviewed, or not written in English, articles that had no focus on gamification (i.e., they dealt with related concepts such as serious games or gamification was only briefly addressed in the paper) or researched gamification in a non-healthcare context, and articles that were not full papers (i.e., grey literature, work-in-progress papers, cover stories, books, or posters). Overall, the screening of publications resulted in the exclusion of 335 additional publications, which lead to a final set of 74 publications that build the baseline for our citation network.

3.2 Citation Network Analysis

Due to the fast pace and scattered nature of the healthcare gamification literature stream and recent criticism of traditional literature review approaches (Boell and Cecez-Kecmanovic, 2015a, Boell and Cecez-Kecmanovic, 2015b), we augment the structured literature review process by performing a citation network analysis (Jo et al., 2009). In contrast to other methods for systematic literature reviews that aim to standardize reported items (e.g., PRISMA (Moher et al. (2009)) or the coding approach (Webster and Watson, 2002), SNA techniques provide a more objective approach to review relevant literature and allow us analysing the typology of the citation network (e.g., what are the most influential papers) and how the literature recently evolved, thus leading to a more holistic review of the relevant literature.

Citation networks are a special form of social networks, with journals, articles, or authors being represented as nodes and citations being represented as directed edges between two nodes in the network (Jo et al., 2009, Pieters et al., 1999). They illustrate the flow of knowledge within a scientific discipline and have been demonstrated to be a suitable method for investigating the development of a literature stream as well as for enabling the thorough review of the most important concepts researched in the respective literature (Jo et al., 2009, Schmidt et al., 2015). In this research, we represent our citation network as a graph of nodes and directed edges. After identifying the baseline articles for our citation network, we used Scopus to extract bibliographic data of all 74 publications that we identified with our structured literature review and their respective references. We then coded each citation in our baseline of articles and constructed our citation network as follows. First, each publication of the baseline set of articles as well as each cited publication in the baseline set was defined as a node in our network graph. Next, we added directed edges for each citation between our baseline articles and cited articles to the network. Overall, this process resulted in a directed graph with 2,457 nodes and 3,000 edges. Figure 2 shows our citation network graph and provides some noteworthy graph parameters.

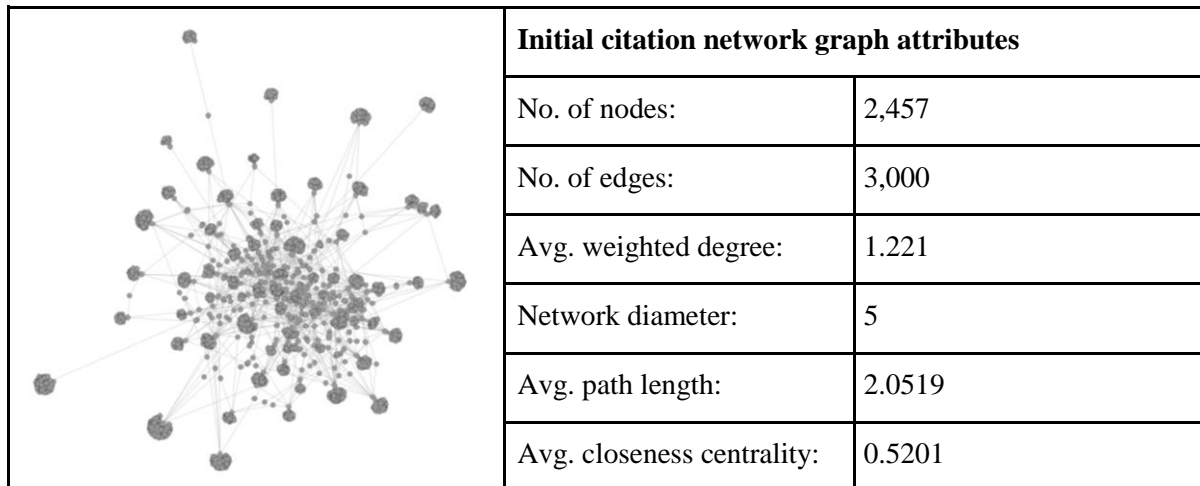


Figure 2. Initial citation network graph and noteworthy parameters.

As a special form of a social network, our citation network and the related graph allow for the application of already established SNA methods (Jo et al., 2009, Otte and Rousseau, 2002, Phillips and Phillips, 1998). To investigate the recent development of research on healthcare gamification, we conducted a main path analysis. Main path analysis involves identifying the most representative articles at different points in time as well as their chronological development (Lucio-Arias and Leydesdorff, 2008). The rationale behind utilizing main path analysis is that articles that integrate information from several previous articles and generate substantial new knowledge receive many citations and are thus crucial for linking other important articles in a citation network (De Nooy et al., 2011). In order to identify these central articles, the traversal count of the articles in the network have to be calculated. Traversal counts describe the extent to which an article is needed for linking other articles in the network. Thus, articles with the highest traversal counts in the citation network can be regarded as essential for the research topic. In accordance with established recommendations for citation network analysis (Lucio-Arias and Leydesdorff, 2008), we used the search path link count (SPLC) algorithm to calculate traversal counts in our network graph.

As stated before, main path analysis assigns high traversal counts to such articles that integrate knowledge from several previous articles. Thus, main paths only comprise articles that are found in the baseline literature (in our case literature on healthcare gamification) because the citation network does not contain information on references of other articles. However, for healthcare gamification it is likely that some essential articles originate from other research fields (e.g., from general gamification literature and literature on health behaviour change) and are thus not represented in the main path. To overcome this shortcoming, we also utilized k-core graph analysis and out-degrees to gain additional insights into our citation network. A k-core graph includes all nodes which have at least k direct neighbours, represented through edges to at least k other nodes in the network (Wasserman and Faust, 1994). Thus, k-core graphs are especially suitable to identify those articles within our citation network that carry out a high degree of knowledge transfer with other articles from the network. In combination with out-degree measures, k-core graphs help us to identify those articles that are especially often cited and thus provide a high amount of knowledge to other articles within the network.

3.3 Concept-Centric Literature Analysis

Building up on the identification of the baseline literature on healthcare gamification, we conducted a manual content analysis targeting to identify the context of healthcare gamification, past research foci and future research opportunities. In order to do so, two researchers independently coded the 74 articles obtained via the structure literature review in stage 1 with regard to the stated concepts. After this evaluation, in a first step the authors compared their results regarding the context of gamification for every paper. In cases where codes deviated, the authors reviewed and discussed the respective article until consensus was reached. It is noteworthy that not every article could be assigned to a single con-

text. Thus, some articles were assigned with multiple contexts. Articles that do not cover a specific context but rather investigate healthcare gamification in general were assigned with the context-code ‘broad’. In a second step, the authors discussed the additional coding results and jointly developed a table including all identified past research foci and future research opportunities with regard to the respective context of healthcare gamification. An extract of this table can be found in section four.

4 Findings and Results

4.1 Central Research Articles on Gamification in Healthcare

Figure 3 shows the main path graph including the traversal counts (SPLC) for all article relationships. The main path analysis revealed an article about the influence of social factors on attitude and intention to continuously use gamified exercise systems by Hamari and Koivisto (2013) as starting point for recent research on healthcare gamification. Building on this, a series of further articles by Juho Hamari and Jonna Koivisto shape the main path of research on healthcare gamification (Hamari and Koivisto, 2014, Hamari and Koivisto, 2015, Koivisto and Hamari, 2014). In addition, the main path analysis reveals the literature reviews by Lewis et al. (2016) and Johnson et al. (2016) as central articles in the domain of healthcare gamification.

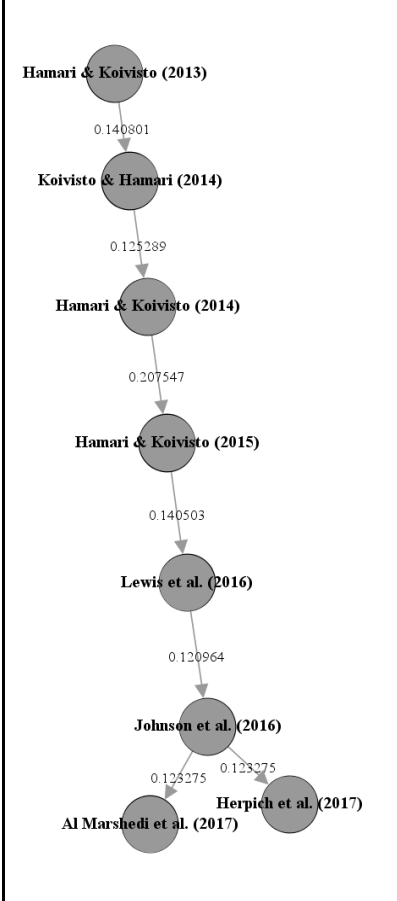
	Edges	Traversal Counts (SPLC)
	Hamari & Koivisto (2013) → Koivisto & Hamari (2014)	0.140801
	Koivisto & Hamari (2014) → Hamari & Koivisto (2014)	0.125289
	Hamari & Koivisto (2014) → Hamari & Koivisto (2015)	0.207547
	Hamari & Koivisto (2015) → Lewis et al. (2016)	0.140503
	Lewis et al. (2016) → Johnson et al. (2016)	0.120964
	Johnson et al. (2016) → AlMarshedi et al. (2017)	0.123275
	Johnson et al. (2016) → Herpich et al. (2017)	0.123275

Figure 3. Main path analysis results.

Figure 4 shows a visualization of the degenerated 6-core graph of the citation network with node sizes proportional to out-degree values. We decided to use a k-value of six as this was the highest k-value for which a k-core graph existed and it thus provided a suitable degeneracy of the graph to identify central articles. The 6-core graph contains the 22 nodes of the citation network that are the most inter-related with each other. k-core analysis can be used to identify groups in a given network when weakly

connected groups split up into multiple subgraphs at certain k-values (De Nooy et al., 2011). Thus, it is noteworthy that that the citation network on healthcare gamification does not split up into subgraphs which indicates the presence of one single highly connected core of relevant articles for the whole research field.

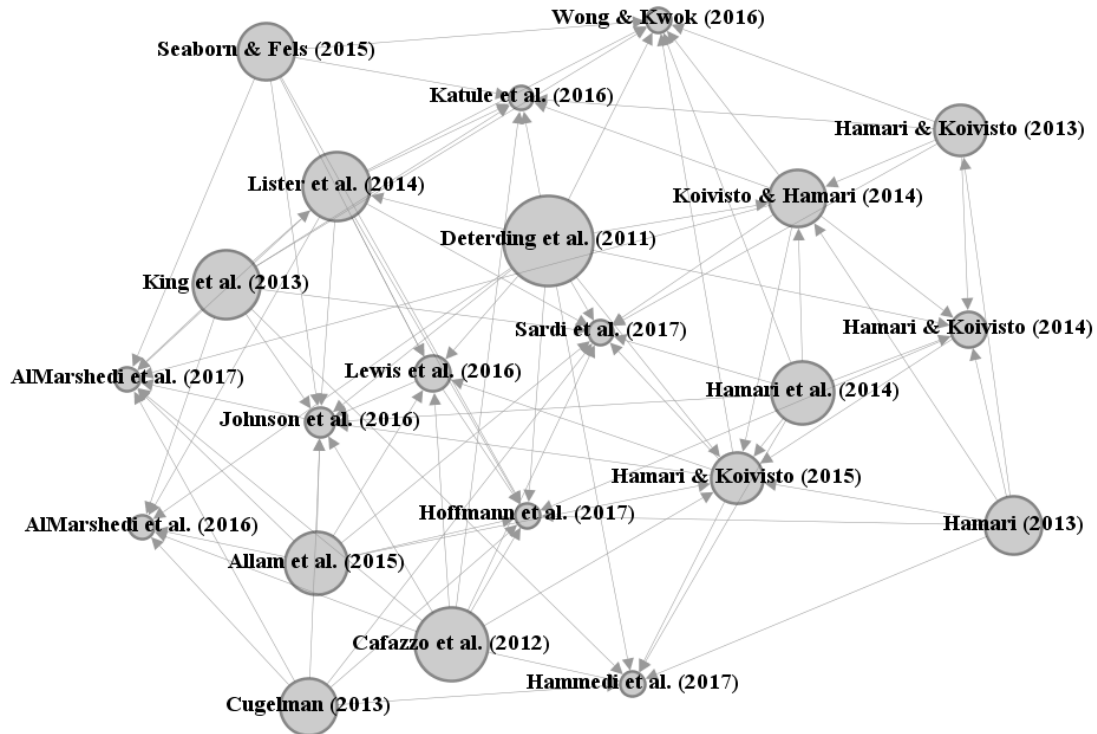


Figure 4. 6-core graph visualization.

In addition to performing k-core analysis, we calculated out-degree values (in a citation network: the frequency an article has been cited by other articles within the network) and closeness centrality (the sum of the length of the shortest paths between the node and all other nodes in the graph) for every article. Table 2 shows the articles of the citation network with an out-degrees of 10 or higher indicating the most influential articles for healthcare gamification. Of these seven articles, two articles arise from general literature on gamification (Deterding et al., 2011, Hamari et al., 2014), two articles are editorials pointing out the relevance of research on healthcare gamification (Cugelman, 2013, King et al., 2013), and three articles are full research articles from the field of healthcare gamification (Cafazzo et al., 2012, Koivisto and Hamari, 2014, Lister et al., 2014).

Article	Out-degree	Closeness centrality
Deterding et al. (2011)	29	0.8086
Hamari et al. (2014)	22	0.775
King et al. (2013)	16	0.625
Cugelman (2013)	15	0.9412
Lister et al. (2014)	13	0.9334
Cafazzo et al. (2012)	13	0.7143
Koivisto & Hamari (2014)	11	0.6923

Table 2. Out-degree values and closeness centrality scores for selected articles.

4.2 Context and Research Gap Analysis on Gamification in Healthcare

Based on the 74 baseline articles identified during the systematic literature review, we performed a manual content analysis in order to identify (1) the main contexts of research on healthcare gamification as well as respective (2) past research foci and (3) opportunities for future research. Table 3 provides an extract of the most relevant findings for the six distinct contexts we identified during the literature analysis and literature that was not conducted in a specific healthcare context (coded as ‘broad’). Overall, 26 articles dealt with gamification for exercise and physical activity, 16 articles dealt with gamification in a broad healthcare context, nine articles dealt with gamification for self-management of chronic diseases (e.g., diabetes, asthma), six articles dealt with gamification for nutrition and healthy food consumption, four articles dealt with gamification for mental health care, three articles dealt with gamification for rehabilitation systems, and three articles dealt with gamification in educational systems for medical professionals. Moreover, nine articles dealt with very specific contexts (e.g., HIV prevention, smoking cessation, compliance with hygiene instruction) that no other article investigated. Those articles alone did not contain enough information on past research foci and future research opportunities and thus were not classified and not integrated within the table.

Gamification Context	Past Research Focus	Future Research Opportunities (Extract)
Exercise & Physical Activity	<ul style="list-style-type: none"> • Demographic differences in perceived benefits from gamification in the context of exercise (Koivisto and Hamari, 2014) • Evaluation of special requirements by older adults regarding gamified exercise systems (Kappen et al., 2016, Takahashi et al., 2016) • Effects of competition in gamified systems fostering physical activity The role of social influences and competition in gamified exercise systems (Chen and Pu, 2014, Hamari and Koivisto, 2013, Hamari and Koivisto, 2015, Shamel et al., 2017) • Design and evaluation of gamification concepts for specific physical activity applications containing multiple gamification elements (Buchem et al., 2015, Ryan et al., 2017, Thorsteinsen et al., 2014, Wu et al., 2015) • The interplay between wearables and gamification elements (Buchem et al., 2015, Chung et al., 2017, Zhao et al., 2017) 	<ul style="list-style-type: none"> • Investigating the role of users' level of experience with the regarded exercise on gamification effects (Geelan et al., 2016) • Examining negative consequences of gamification in gamified exercise systems (Barratt, 2016) • Exploring the effects of gamification on users with different exercise goals (e.g.: leisure vs. fitness) (Zhao et al., 2017)
Nutrition	<ul style="list-style-type: none"> • Effects of virtual rewards on 	<ul style="list-style-type: none"> • Designing effective gamified appli-

	<p>self-determination in gamified nutrition applications (Katule et al., 2016b)</p> <ul style="list-style-type: none"> • Investigation of effects of gamification on healthy food consumption by children (Jones et al., 2014a, Jones et al., 2014b) 	<p>cations fostering healthy food consumption that employ principles of social learning theory (Jones et al., 2014b)</p> <ul style="list-style-type: none"> • Exploring the effects of intermediaries on the use of gamified applications fostering healthy food consumption by target beneficiaries (Katule et al., 2016a, Katule et al., 2016b)
Mental health care	<ul style="list-style-type: none"> • Analysis of hindering factors, promoting factors, and requirements for gamification in mental healthcare from the perspective of users and health professionals (Hopia and Raitio, 2016) • Interventions using gamification features for the treatment of depression (Brown et al., 2016, Fleming et al., 2017) 	<ul style="list-style-type: none"> • Examining the role of gamification on program adherence in mental health care (e.g., through analysis of log data) (Brown et al., 2016) • Investigating gamification effects on mental health disorders other than depression (Brown et al., 2016)
Self-Management of chronic diseases	<ul style="list-style-type: none"> • Gamification design principles and gamification frameworks for health applications for chronic disease management (AlMarshedi et al., 2016, AlMarshedi et al., 2017, AlMarshedi et al., 2015, Miller et al., 2016) • Short-term effects of gamification usage to increase adherence of home-monitoring (Cafazzo et al., 2012, Elias et al., 2013) (Elias et al., 2013) 	<ul style="list-style-type: none"> • Empirical validation of gamification design principles and gamification frameworks for health applications for chronic disease management (AlMarshedi et al., 2017, Miller et al., 2016) • Examining novelty effects of gamification on the adherence of home-monitoring (Cafazzo et al., 2012, Elias et al., 2013, Theng et al., 2015) • Investigating the effect of gamification on medication adherence (Theng et al., 2015)
Rehabilitation	<ul style="list-style-type: none"> • Discussion of strategies and frameworks for playful design and gamification in therapeutic movement games (Dithmer et al., 2016, Jung et al., 2017, Korn and Tietz, 2017) 	<ul style="list-style-type: none"> • Discussing the need to limit the amount of fun in gamified rehabilitation systems (Dithmer et al., 2016, Korn and Tietz, 2017) • Measuring the impact of gamification not only by self-assessment but also by actual rehabilitation success and health improvements (Korn and Tietz, 2017) • Assessing the effects of gamification in different phases of the rehabilitation process (Dithmer et al., 2016)
Education of med-	<ul style="list-style-type: none"> • Influence of intrinsic and ex- 	<ul style="list-style-type: none"> • Exploring the effects of self-efficacy

<p>ical professionals</p>	<p>trinsic motivation on user engagement in gamified learning systems for medical education (McLeod et al., 2017)</p> <ul style="list-style-type: none"> • Assessment of acceptance and use of gamified learning systems for medical education (Nevin et al., 2014) 	<p>and voluntariness on user engagement in gamified learning systems for medical education (McLeod et al., 2017)</p> <ul style="list-style-type: none"> • Investigating the effects of gamification in medical learning environments on objective educational measures (e.g., exam scores) (Nevin et al., 2014) • Examining the effects of single game elements on user encouragement in gamified learning systems for medical education (Nevin et al., 2014) • Investigating in which stages of the education process, gamification can be particularly valuable (Chen et al., 2017)
<p>Broad</p>	<ul style="list-style-type: none"> • Gamification strategies employed in e-health applications (Alahäivälä and Oinas-Kukkonen, 2016, Johnson et al., 2016, Sardi et al., 2017) • Benefits and pitfalls of using gamified e-health applications (Sardi et al., 2017) • Current use of rewards in gamified health applications (Lewis et al., 2016, McDaniel, 2016) • Assessment of multiple game design elements at once (Johnson et al., 2016) • Analysis of embedded behaviour change techniques in gamified health applications (Edwards et al., 2016, Lister et al., 2014) • Proposition of gamification-based Frameworks (Helf et al., 2015) 	<ul style="list-style-type: none"> • Association of a behaviour change theory with the gamification process (Sardi et al., 2017) Investigating the effects of individual game design elements in isolation (Johnson et al., 2016, Ryan et al., 2017) • Studying complementary effects between different gamification elements (Wu et al., 2015) • In-depth studies and evaluations of the potential of gamification to change health behaviours including sufficient sample size and long-term studies (e.g., randomized control trials) (Edwards et al., 2016, Johnson et al., 2016) (Lister et al., 2014) • Investigating perceptions of companies operating in the field of health and wellness regarding the use of gamification in their services (Kari et al., 2016a) • Examining the effects of cultural differences on the effects of gamification in health applications (Koivisto and Hamari, 2014, Spil et al., 2017) • Investigating how the necessity to acquire and use new skills to participate in the gamification system influences the effects of gamification (Hammedi et al., 2017) • Examining whether gamification in-

		<p>duces a shift of roles for users and service providers (Hammedi et al., 2017)</p> <ul style="list-style-type: none"> • Studying the relationship of personality traits and player types to gamification (Hamari and Koivisto, 2013, Katule et al., 2016b, Koivisto and Hamari, 2014, Orji et al., 2017)
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Table 3. Past research foci and opportunities for further research in healthcare gamification.

5 Discussion

Building upon our research questions, our research objective was the analysis of recent research developments on healthcare gamification and the identification of the most essential articles in the research domain. Moreover, we aimed to identify past research foci as well as opportunities for future research for different contexts of healthcare gamification in order provide researcher with potential avenues for exciting future research projects. Based on the results described in section four, we were generally able to provide answers for our research questions and thus enhanced the knowledge base on healthcare gamification research. We discuss some of the most interesting findings and their implications in the following.

Applying social network analysis methods to the citation network revealed interesting insights into the structure of the healthcare gamification field. First, the main path analysis revealed the overwhelming influence of a series of papers by Juho Hamari and Jonna Koivisto between 2013 and 2015 on the development of the research field. However, the most recent developments show that publications by other authors such as the literature reviews by Lewis et al. (2016) and Johnson et al. (2016) are also acknowledged, cited well by the research community, and play a key role in the transfer of knowledge between members of the research community. Second, the short temporal distances between the different nodes of the main path indicate that members of the research community quickly react to new developments within the research field and methodically build new research based on already acquired knowledge. However, when comparing our k-core graph analysis with k-core graphs of other, more mature, research fields it becomes clear that research on healthcare gamification is still in its infancy. For example, Schmidt et al. (2015) developed a citation network for literature on client-vendor relationships in IT outsourcing building on a literature baseline of 40 articles and calculated the highest possible k-core graph. This resulted in a 7-core graph containing 51 articles. Thus, we conclude that literature on IT outsourcing is significantly stronger interrelated than literature on healthcare gamification. From our point of view, this is not surprising as research on gamification is still emerging and thus high quality publications are sparse (Hamari et al., 2014, Johnson et al., 2016). However, our k-core analysis and analysis of out-degree and closeness centrality values also indicate that a small core of highly relevant publications within the research area exists that is frequently used by researchers. Another interesting finding from k-core and out-degree value analysis is that the experience view on gamification that has been coined by Huotari and Hamari (2012) (Kari et al., 2016b) is not widely adopted in healthcare gamification research. Instead, researchers rather focussed on utilizing the process view on gamification by Deterding et al. (2011). Future research might address this gap by concentrating on using the experience view and elaborating on its consequences for healthcare gamification research.

The concept-centric analysis of the 74 baseline articles identified in the systematic literature review revealed the most frequently researched healthcare gamification contexts. 26 of 74 article dealt with gamified systems in the context of exercise and physical activity. Thus, this context was the most commonly investigated one within the baseline literature. In addition, 16 of 74 articles dealt with gamification in a broad health context. This highlights that more than 55% of articles within the baseline literature dealt with on of these contexts. Other highly interesting contexts such as gamification of re-

habilitation (three articles), gamification for mental health care (four articles) or gamification for smoking cessation (one article) have only been researched sparsely until now. Thus, these contexts leave room for various possibilities for future research. By using concept-centric analysis, we were able to identify emergent research opportunities as well as the foci of past research in healthcare gamification. Besides the call for more rigorous research containing large sample sizes and long-term studies which has been made by various authors (e.g., Hamari et al., 2014, Johnson et al., 2016), we were able to extract and outline highly interesting and relevant research opportunities from the baseline literature. These research opportunities include, among others, the call for more research on perceptions of companies operating in the field of health and wellness regarding the use of gamification in their services (Kari et al., 2016a), the study of complementary effects between different gamification elements (Wu et al., 2015), and the investigation of relationships of personality traits and player types to gamification effects (Hamari and Koivisto, 2013, Katule et al., 2016b, Koivisto and Hamari, 2014, Orji et al., 2017). Future researchers that are interested in the domain of healthcare gamification might use our findings as a roadmap that assists them in identifying interesting research problems.

To the best of our knowledge, there is no study available using SNA methods for research on healthcare gamification. Using SNA methods for visualization and analysis of the literature on healthcare gamification enabled us to evaluate a large number of articles in a short period of time and with appropriate effort. The results of our study indicate that SNA methods are suitable for literature reviews in the field of healthcare gamification as it enables the evaluation of a large number of articles in a time and effort-efficient way and thus provides valuable insights in the scattered and fast-paced landscape of healthcare gamification research.

Although we were able to provide adequate answers concerning our research questions and thus contributed to the knowledge on healthcare gamification research, our study is limited by a number of factors that we briefly outline in the following. Some general issues with the utilization of citation networks exist that are also valid within the context of our research. In our approach of citation network analysis, we used the citation lists of all articles identified as our baseline literature. Thus, we did not take into account how often a source is cited within another article. This is relevant as one might argue that a source that is cited frequently within an article is more central for the article than a source that is only cited once. Another important issue of SNA is that it can result in biased outcomes due to frequent citations of very important articles or articles from close colleagues of the author (Schmidt et al., 2015). A manual evaluation of all articles would help to eliminate those biases. However, this was not feasible in the context of this study as we analysed more than 2,400 articles. Future literature reviews using other methodologies (e.g., text mining approaches) might help to overcome these limitations and further verify the results of our study. In this work, we purposely narrowed the scope of our research on gamification in healthcare contexts. However, we think that future research might also take into account to use SNA in order to analyse the body of knowledge on gamification in other research domains (e.g., education) and comparing it with the body of knowledge on healthcare gamification.

6 Conclusion

Healthcare gamification is a fast-growing and inherently interdisciplinary stream of research. Within this study, we utilized SNA methods and manual concept-centric analysis to identify the most important articles and authors as well as research contexts and knowledge gaps on healthcare gamification. By doing so, we provided a comprehensive overview of the research domain and provide avenues for future research in this domain. Using SNA methods enabled us to process a large number of articles in a short period of time. Thus, we would like to encourage other researchers to use SNA approaches on gamification literature in order to further strengthen our knowledge about this highly relevant and dynamic research field.

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