

Healthcare gamification: Science mapping the body of literature

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ABSTRACT

Healthcare gamification is a research topic being investigated in numerous contexts. As it is an interdisciplinary subject, it is hard for researchers to keep up with the research published in these venues. This paper aims to unveil the intellectual structure of the healthcare gamification research field through a systematic literature review. We apply a science map strategy to a 520-document database. This database was analyzed to build an evolutionary map revealing the most co-cited authors, their publications, and the theories used. Results evidence that referenced research can be classified into six research traditions. Finally, research opportunities are presented.

Keywords: Healthcare gamification, SciMAT, co-citation, intellectual structure.

INTRODUCTION

Healthcare Gamification Scattered Research Field

Gamification is defined as "the use of game design elements in non-game contexts" (Deterding *et al.*, 2011a:2). During the last years, gamification has been recognized as a promising trend as pieces of evidence of its effectiveness exist (Koivisto & Malik, 2021). So far, many different gamification studies have been developed in diverse contexts, such as education, social networks, online communities, sustainability, marketing, and healthcare.

In the healthcare context, numerous subareas of gamification research arose. For example, studies exist in gamification for supporting the practice of exercises and physical activity, correcting nutrition imbalance, advancing mental health care, allowing the self-management of chronic diseases, supporting physical rehabilitation, and helping the education of medical professional.

Healthcare gamification is considered a valuable means to engage different interest groups in healthier behaviors (Schmidt-Kraepelin *et al.*, 2018) and positively spawn enjoyment, compliance with health-related activities, and effective health outcomes (Stepanovic & Mettler, 2018). Consequently, gamified healthcare-related initiatives have been developed in many significant ways. Whereas World Health Organization (WHO) has emphasized health technology as an indispensable means for achieving effective and efficient prevention, diagnosis, treatment, and rehabilitation of diseases, with the help of gamification, it became feasible to attain the health-related development goals listed in the Millennium Declaration (World Health Organization, 2007).

Because gamification is such a promising approach to stimulating health behavior change (Johnson *et al.*, 2016), it has fostered fast-growing research streams with multiple venues yet to be explored (see Johnson *et al.*, 2016; Schmidt-Kraepelin *et al.*, 2018). However, the spread of interest in this multidisciplinary topic has led to a profusion of research publications and a multiplicity of journals that are troublesome for researchers to stay updated with the knowledge developed (Schmidt-Kraepelin *et al.*, 2018).

Researchers interested in studying healthcare gamification face the problem of dealing with much new knowledge scattered along multiple scientific outlets. Successful researchers have to work with literature reviews because new knowledge generation requires establishing of a critical foundation for its advancement (Webster & Watson, 2002). Literature reviews are helpful to evaluate the breadth of a specific research domain, synthesize it, develop theories and provide a conceptual background for the flourishing of new studies on the topic, which will explore the topics that require further investigation (Paré *et al.*, 2015). Knowledge accumulation is fundamental for a field to be recognized as scientific and consequently develop (Paré *et al.*, 2015), and literature reviews are a crucial strategy to obtain a comprehensive overview of a topic (Green, Johnson & Adams, 2006).

Despite the multiplicity of approaches of types of literature reviews on healthcare gamification (e.g., Hamari, Koivisto & Sarsa, 2014; Seaborn & Fels, 2015; Theng *et al.*, 2015; Alahaivala & Oinas-Kukkonen, 2016; Lewis, Swartz & Lyons, 2016; Johnson *et al.*, 2016; Matallaoui *et al.*, 2017; Sardi, Idri & Fernández-Alemán, 2017; Schmidt-Kraepelin *et al.*, 2018), none of them has been so far conducted based on co-citation science maps, a notable strategy that can reveal important research traditions,

prominent authors and publication venues on the topic (Shafique, 2013). Fortunately, a specific variant of literature review can perform this analysis by providing the intellectual structure (InS) of a topic. InS is defined as "a set of salient attributes of the knowledge base that can provide an organized and holistic understanding of the chosen scientific domain (...) its constituent research traditions, their disciplinary composition, topics addressed by these, and the pattern of their interrelationships" (Shafique, 2013:63).

Revealing healthcare gamification InS is a promising strategy to promote a deeper understanding of this research area and complementarily identify some of its relevant investigation opportunities. In consequence, we performed a systematic literature review by applying InS techniques (Shafique, 2013) over a 520-document database, published from 2012 to 2020, to provide an extensive view of this field by identifying the essential research traditions, the prominent authors, the publication venues (from both journal and conferences) and the relevant documents researched all across the studied timeframe.

In the following sections, this research is structured as follows: The next part will cover some past literature reviews in healthcare gamification; followed by a methodology section, covering central methodological procedures adopted by this research; a results exposition part, where co-citation analysis findings are depicted; a discussion section, where these results are related to actual healthcare gamification literature and finally a conclusion part where authors highlight the outcomes of this research.

LITERATURE REVIEW

An Overview of Healthcare Gamification Literature Reviews

Gamification is a way to incentive people to change behaviors and reinforce desired behavioral traits (Schmidt-Kraepelin *et al.*, 2018). Many literature reviews on gamification in general and healthcare gamification exist. Table 1 offers a summary of these studies. We group them into three distinct groups. The first group contains studies that developed initial reviews of gamification in general terms. They are focused on clarifying if gamification is an effective strategy (Hamari, Koivisto & Sarsa, 2014) and how gamified interventions can be predicted by gamification theories (Seaborn & Fels, 2015). Both studies do not focus on healthcare gamification. The second group developed literature reviews focused on topics like investigating gamification and videogame effects on diabetes self-management (Theng *et al.*, 2015), the use of contextual information on the development of healthcare gamified interventions (Alahaivala & Oinas-Kukkonen, 2016), how the rewards gamification element was used on the healthcare context (Lewis, Swartz & Lyons, 2016), and how gamified interventions were used for exercising (Matallaoui, 2017). Finally, the third group in which our study can be added is set to explore gamified interventions with healthcare systems. The studies in this group looked for pieces of evidence of healthcare gamification effectiveness, how it was used, what audiences and healthcare domains were targeted (Johnson, 2016), and aimed to point out the essential articles and authors, past research foci, and potential future research gaps (Schmidt-Kraepelin, 2018).

It is worth mentioning that none of the reviews above provides an analysis of the intellectual structure of the healthcare gamification literature.

Table 1: Literature reviews on general gamification and healthcare gamification.

Author(s)	Articles	Range	Method	Context	The focus of the analysis	Keywords/Search string	Databases
Hamari, Koivisto & Sarsa (2014)	24	2008 - 2013 ¹	Meta-analysis	General	Empirical findings on implemented motivational affordances and related psychological and behavioral outcomes in gamified systems.	gamification, gamif*, gameful and motivational affordance.	Scopus, ScienceDirect, EBSCOHost, Web of Science, ACM Digital library, AISel, Google Scholar, and Proquest.
Seaborn & Fels (2015)	30	2013	Meta-analysis	General	Applied and evaluated examples of gamification and conceptual work.	gamification OR gamif*	EBSCOhost, JSTOR, Ovid, ProQuest, PubMed, Scopus, and Web of Knowledge
Theng <i>et al.</i> , (2015)	10	2000 – 2014	Meta-analysis	Healthcare	The use of games, gamification, and virtual environments for diabetes self-management.	diabetes with gamifi* OR virtual reality OR virtual environment OR video gam* OR mobile gam* OR computer gam*	PubMed, Web of Science, Scopus, and PsychINFO
Alahaivala & Oinas-Kukkonen (2016)	15	2011 – 2015	Meta-analysis	Healthcare	Persuasion contexts of gamified health behavior support systems.	gamif* and health*	Elsevier Scopus, ISI Web of Science, PubMed, EBSCOHost, ACM Digital Library, and IEEE Explore.
Lewis, Swartz & Lyons, (2016)	18	Undefined – 2015	Meta-analysis	Healthcare	The use of reward systems in health-related gamified interventions.	Gamification was truncated to gamif*; Rewards was truncated to reward*, incentive*, reinforce*, conting*, motivate*, encourag*, entic*, or point*. "Intervention" was truncated to interven* or randomiz*	Medline OVID, Medline PubMed, Web of Science, CINAHL, Cochrane Central, and PsycINFO.
Johnson <i>et al.</i> , (2016)	19	Undefined – 2015	Meta-analysis	Healthcare	Empirical findings on the effectiveness and quality of health and well-being gamification applications.	Gamif* AND (health OR mental OR anxi* OR depres* OR wellbeing OR wellbeing)	Ebscohost, ProQuest, Association for Computing Machinery (ACM), IEEE Xplore, Web of Science, Scopus, Science Direct, and PubMed.
Matallaoui <i>et al.</i> , (2017)	25	Every paper published before 2015	Meta-analysis	Healthcare	Empirical findings on gamified systems and serious games for exercising. Review of deployed motivational affordances and the effectiveness of gamification features in exergames	(TITLE-ABS-KEY (virtual realit*) AND (TITLE ABS-KEY (exerc*) OR TITLE ABS-KEY(physical activ*)) AND TITLE-ABS KEY (gam*) AND NOT (TITLE-ABS-KEY (therap*) OR TITLE-ABS-KEY (rehab*)))	Scopus
Sardi, Idri & Fernández-Alemán, (2017)	46	2000 – 2015	Meta-analysis	Healthcare	Benefits and pitfalls of employed gamification strategies and serious games in e-Health.	(App* OR framework* OR system* OR electronic*) AND (*health* OR *PHR* OR *EHR* OR medic* OR clinic* OR patient*) AND (gamif* OR game elements OR game* OR game mechanics)	IEEE-Xplore, ACM Digital Library, ScienceDirect, SpringerLink, Wiley Interscience, PubMed, and GoogleScholar.

Author(s)	Articles	Range	Method	Context	The focus of the analysis	Keywords/Search string	Databases
Schmidt-Kraepelin <i>et al.</i> , (2018)	74 / 2.457	2009 – 2018	Citation Network Analysis	Healthcare	Recent developments of research on healthcare gamification, past research foci, and knowledge gaps.	TITLE-ABSTR KEY(Gamif*) and TITLE-ABSTR-KEY(health* OR medic* OR exer* OR life* OR therap* OR fitness OR patient OR wellness)	IEEEExplore, EBSCO Host, ACM Digital Library, Science Direct, PubMed, ProQuest, and AISel
This research	520 / 17.169	2012 -2020	Science Map	Healthcare	Healthcare gamification main referenced authors and researched topics	(Gamif*) and medic* OR exer* OR life* OR therap* OR fitness OR patient OR wellness	Scopus

Source: Adapted from (Schmidt-Kraepelin *et al.*, 2018). ⁴the authors do not mention a time range of the database search, but articles reported were published from 2008 to 2013.

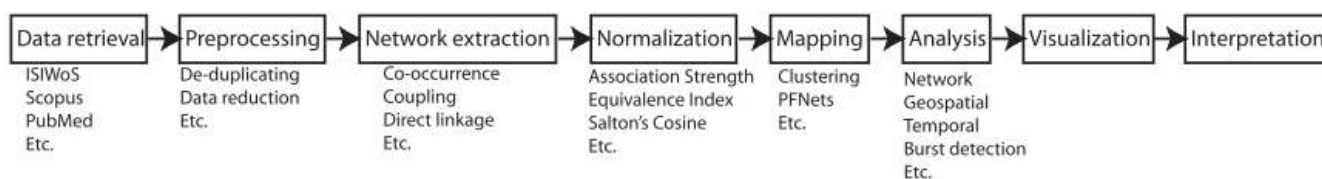
METHODOLOGICAL PROCEDURES

Science Mapping

Our literature review allows composing the InS of healthcare gamification longitudinally. This approach is different from previous literature reviews. Some streams explored gamification in a general way (e.g., Hamari, Koivisto & Sarsa, 2014), while others explored specific healthcare gamification scenarios (e.g., Theng *et al.*, 2015) and focused on studying the healthcare gamification empirical findings (Johnson, *et al.*, 2016), explored the rewards systems used in gamification interventions (Lewis, Swartz & Lyons, 2016), investigated the persuasion contexts in which gamification was implemented (Alahaivala & Oinas-Kukkonen, 2016). Still some focused on identifying healthcare gamification's recent developments (Schmidt-Kraepelin *et al.*, 2018). We applied science mapping to explore healthcare gamification.

The science mapping strategy exhibits structural and dynamic aspects of scientific research by applying co-citation analysis techniques (Cobo *et al.*, 2011a). The dynamic aspects of the advancement of the topic literature are observed by denoting how the changing structure transforms over time (Börner, Chen & Boyack, 2003). The intellectual structure of a research area comprises a set of salient attributes, such as its research traditions, disciplinary composition, topics addressed, and patterns of their interrelationships, that provide an understanding of any specific scientific domain (Shafique, 2013). A research tradition "refers to a fairly broad but distinguishable part of scientific literature in a field of research. It is a coherent collection of various subgroups of research themes/fronts that are identifiable through shared topic and common theoretical perspectives" (Shafique, 2013:62). When published documents are treated as points within a research field and related according to their co-citation levels, it becomes possible to create maps revealing the disciplines that these documents belong to, their authors, themes, and the relationship between all these aspects (White & Griffith, 1981).

In practice, science mapping is grounded on the quantitative approach of bibliometric research methods to create a visual representation of the structure of the research area built by clustering the research area elements (e.g., documents, words, journals) (Zupic & Cater, 2015). We use the procedures described by previous literature on the method (Cobo *et al.*, 2011a; Cobo *et al.*, 2011b; Cobo *et al.*, 2012; Shafique, 2013), which are composed by eight steps: data retrieval, preprocessing, network extraction, normalization, mapping, analysis, visualization, and interpretation (Figure 1).



Source: Cobo *et al.*, 2012.

Figure 1: Science mapping workflow.

Plenty of analytical software exists to support science mapping. For more information on the pros and cons of each software, see the review by Cobo *et al.* (2011a). Our study adopted SciMAT (Cobo *et al.*, 2012). The main advantages of SciMAT over other science mapping tools are "the capability to choose the methods, algorithms, and measures used to perform the analysis through the configuration wizard; (...) the use of impact measures to quantify the results; (...) the ability to perform all the steps of the science mapping workflow" (Cobo *et al.*, 2012:1627).

Data Collection

We based the data retrieval phase on the Scopus database. Most bibliometric software packages support the Scopus data importing process - SciMAT included - and is more accurate for developing co-citation, as it offers data for every author and reference cited (Zupic & Cater, 2015). We searched a research string to find relevant documents based on Schmidt-Kraepelin (2018) (see Table 2 for further details on database retrieval). They developed what was - until the realization of this specific research initiative, to the best of our knowledge - the most extensive literature review on healthcare gamification published, selecting 74 documents.

On the data collecting procedure an initial set of 2.134 documents was found from our string application. These documents were filtered, eliminating 301 documents to obtain only conference papers, articles, reviews, and editorials, with the language being English or Portuguese, totaling 1.833 documents left.

Since authors usually cite documents relevant to their work, citations can be used as a proxy of the paper's influence so that it can be considered relevant if an article is heavily cited (Zupic & Cater, 2015). To make the number of documents manageable, we ranked the 1.833 documents by citation and selected the fourth quartile (Q4 - 459 documents). While the full 1.833 documents database represented 12.931 citations, the 459 documents in Q4 represent 88,53% (11.449) of these total citations, which is deemed a good representation of their relevance.

Table 2: Summarized research design.

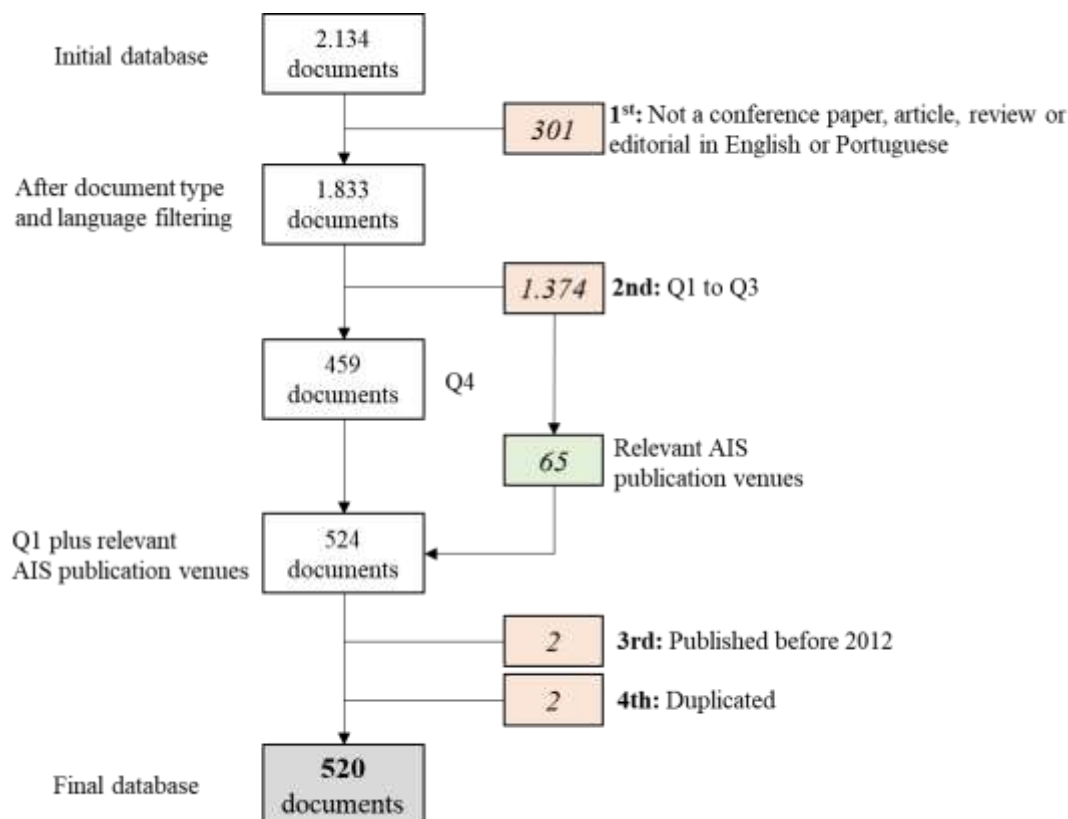
Procedure	Research design
Data retrieval: define the collection parameters and databases to which they will be applied	Research string: article title, abstract, keywords [<i>gamif*</i> AND <i>health*</i>] OR [<i>gamif*</i> AND <i>medic*</i>] OR [<i>gamif*</i> AND <i>exer*</i>] OR [<i>gamif*</i> AND <i>life*</i>] OR [<i>gamif*</i> AND <i>therap*</i>] OR [<i>gamif*</i> AND <i>fitness</i>] OR [<i>gamif*</i> AND <i>patient</i>] OR [<i>gamif*</i> AND <i>wellness</i>]. Database: Scopus. Filtering: a) only conference papers, articles, reviews and editorials, with the language being English or Portuguese, were considered. b) Q4 c) Plus relevant IS publication venues.
Preprocessing: define the preprocessing procedures to be applied to the collected data	Misspelling: authors, documents, journals and references. Deduplication: authors, documents, journals and references.
Network extraction: define the parameters for the network extraction	Periods: Single-year periods (Cobo <i>et al.</i> , 2011a). Unit(s) of analysis: references. Data reduction: Only considered references cited at least two times (Zupic & Cater, 2015).
Normalization: define technique(s) that will be applied to network normalization	Network reduction: Only considered references co-cited at least 2 or 3 times, depending on the subperiod analyzed (Zupic & Cater, 2015). Similarity(ies) measure(s): equivalence index (Cobo <i>et al.</i> , 2011a).
Mapping: define techniques(s) that will be applied to network mapping	Method: simple center algorithm (Cobo <i>et al.</i> , 2011a)
Analysis: define techniques(s) that will be applied to network analysis	Technique(s): Co-citation (Small, 1973) analysis.
Visualization: define technique(s) that will be applied to network visualization	Technique(s): Strategic diagrams and evolution map (Cobo <i>et al.</i> , 2012).
Interpretation: define the interpretation strategy for the study	Strategy(ies): Structure and dynamics (Zupic & Cater, 2015).

Source: Adapted from Zupic & Cater, 2015; Cobo *et al.*, 2012.

To minimize the risk of excluding papers representative of the IS field but conceivably not highly cited ones, we searched within Q1, Q2, and Q3 for documents published in the Senior Basket of 8 journals from the Association for Information Systems (AIS) (AIS, 2011), AIS conferences (AMCIS, ICIS, PACIS, ECIS and HICCS) and the Special Interest Groups (SIGs) SIGHealth and SIGHCI recommended journals lists (AIS, 2011). As a result, we identified 65 additional documents added to the 459 documents in Q4, creating a database of 524 documents.

Only two documents from the collected database were published before 2012. They were excluded for two reasons: our research strategy smooth of data could be avoided if subperiods were divided spanning only one year each (Cobo *et al.*, 2011a), and these individual documents do not represent enough data to obtain information for their respective years. Finally, we ran a deduplication process and eliminated two documents.

This final study database comprises 520 documents published in 352 different publication sources, of which 195 (55,39%) are journals, and 157 (44,61%) are academic events such as congresses, conferences, and symposiums. Figure 2 summarizes the steps of the data retrieval phase.



Source: This study.

Figure 2: Data retrieval process summary.

Documents Processing

The final database passed through a preprocessing phase composed of two steps: misspelling correction and deduplication. The misspelling correction helped correct, for example, author name misspellings. On the other hand, the deduplication process identified and consolidated data from similar documents labeled in slightly different forms.

Cited references (17,169 different cited documents) are used as a basis to build the science maps. The criteria adopted to extract the networks was the co-occurrence relation (Cobo *et al.*, 2012), after which a normalization process was applied (Cobo *et al.*, 2011a) based on the equivalence index (Cobo *et al.*, 2011a).

Co-citation analysis uses reference information (Small, 1973). Co-citation is the "frequency with which two items of earlier literature are cited together by the later literature" (Small, 1973:265). We adopted the equivalence index (Cobo *et al.*, 2011a) to develop the normalization process and the simple center's algorithm (Cobo *et al.*, 2011a) for clustering the documents. Both options fit this study's desired type of analysis (Cobo *et al.*, 2011a; Zupic & Cater, 2015).

RESULTS

An evolutionary map is a tool employed in this phase. It allows revealing the structure of elements that compound the healthcare gamification research field and its associated themes.

Co-Citation Analysis

It is plausible to assume that papers frequently referenced by others represent critical concepts about a specific research field. So, it turns logical to think that co-citation patterns can map similar papers, and their interconnections are an objective means to characterize a research field InS (Small, 1973). Based on these ideas, we identify and describe the main clusters of documents over nine years, from 2012 to 2020, and determine their research traditions. Besides, we also depicted publication venues and theories adopted by these documents.

The first step in building this co-citation analysis is preprocessing the references database. Two processes compose this phase: misspelling and deduplication treatment. For misspelling correction, we searched the whole database for author or document name errors (e.g., SchÄbel, S. to Schöbel, S.). SciMAT allows searching and comparing document titles and the name of authors using Levenshtein distance for deduplication treatment. The whole database was analyzed using this feature, looking for a Levenshtein distance of 1. Following, we manually deduplicated equivalent documents but found multiple wordings (e.g., De Vries, N.M. and de Vries, N.M.), uniformizing them under a single name.

All documents together contained 17.169 unique references. Their citations ranged from 308 (the most cited reference) to 1 (2.598 single cited references). As a reduction criterion, we configured SciMAT to use only references cited a minimum of two times. Consequently, the final database comprised a total of 2.221 unique references. We then extracted only references that cooccurred two times. Figure 3 shows the evolution map generated according to these parameters. We verified thirty-three clusters within the nine one-year periods. The sphere size is related to document quantity in each cluster, a parameter also related to the numbers inside the spheres. The name of the clusters is related to the main cluster document. Primary cluster documents have the highest number of co-citations within the cluster documents. Lines connecting clusters can have two different meanings: a solid line means that the principal author of the cluster is contained within the next cluster, while dotted lines mean that both clusters share elements but not the main one (Cobo *et al.*, 2011a).

Additional Qualitative Analysis

Aiming to reveal how the literature venues evolved, we did a more in-depth analysis within the sixteen clusters with evidence of continuity (those connected by solid or dotted lines). These clusters are composed of 129 unique documents that were individually analyzed.

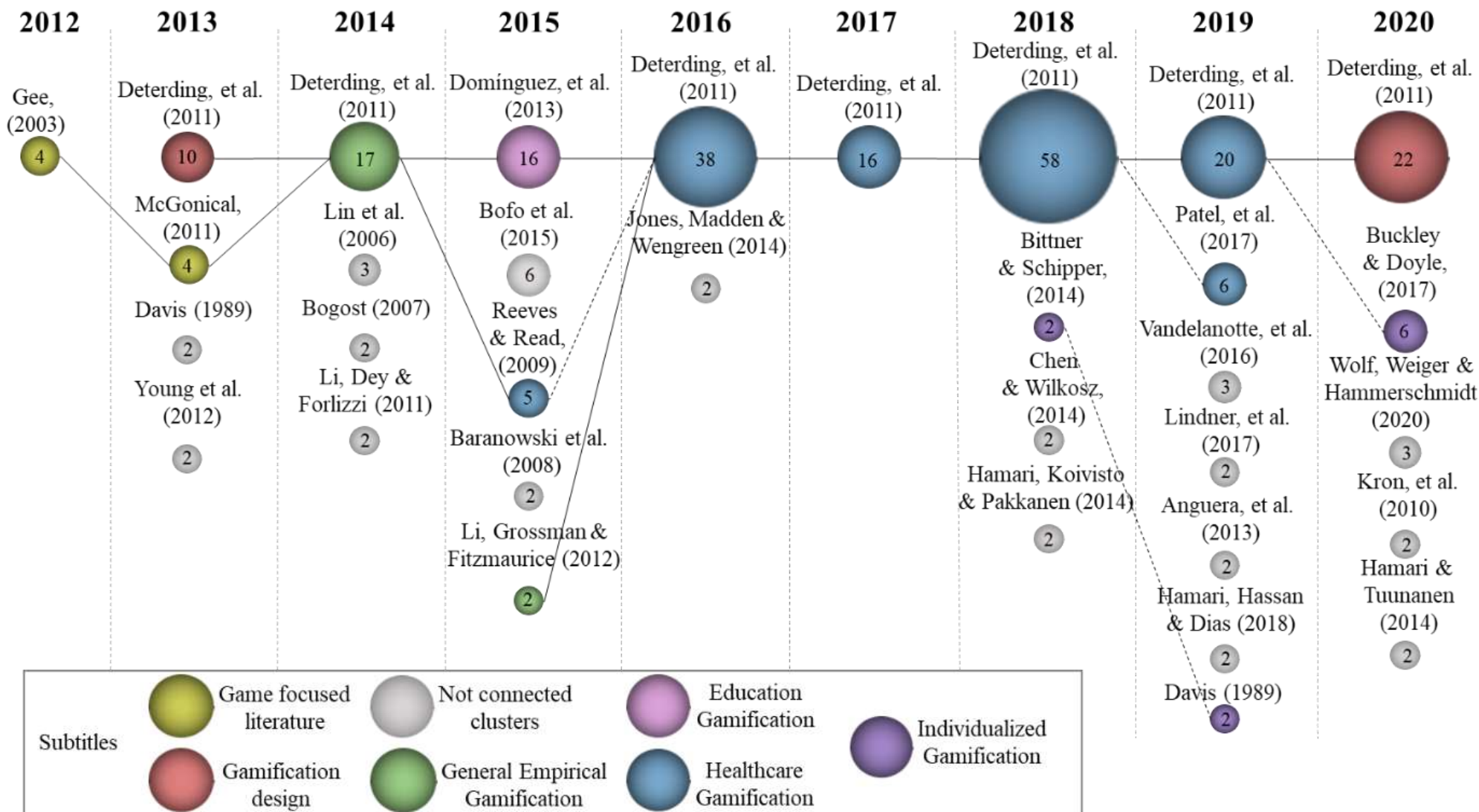
Publication Venue

We explored these documents aiming to identify in which journal they were published and found that documents have been published primarily in scientific journal papers (79 documents) but also in academic events (31 documents), books (18 documents), and magazines (1 document). Table 3 shows the complete list of journals. Within the basket of eight, we found MIS Quarterly (4 papers) and Journal of Management Information Systems (1 paper). The Journal of Medical Internet Research (4 papers) and the International Journal of Medical Informatics (1 paper) are indexed in SIGHealth journal list. We also found papers from Computers in Human Behavior (6 papers) and the International Journal of Human Computer Studies (1 paper) related to the journal list recommended by SIGHCI.

Moving our attention to the academic events, we found that each event registered only one publication, so none of them deserved special attention. However, from the Association for Information Systems (AIS) conferences list, we identified The 21st European Conference on Information Systems, the 2003 Pacific Asia Conference on Information Systems, and the 47th Hawaii International Conference on System Sciences with one publication each.

A diverse number of themes composed the list of books: the Octalysis gamification framework (Chou, 2019), flow theory (Csikszentmihalyi 1975), self-determination theory (Deci & Ryan, 1985), game design principles (Zichermann & Cunningham, 2011), grounded theory methodology (Glaser & Strauss, 1967), and the classical Homo Ludens by Huizinga (2014) who wrote about the act of playing, are some examples.

Finally, Interactions, a magazine published since 1994 by the Association for Computing Machinery and dedicated to professionals, brought Deterding's (2012) article about gamification design to our analysis.



Source: This study.

Figure 3: Evolution map of clusters revealed by co-citation analysis.

Table 3: List of identified journals.

Journal Name	# ¹	Journal Name	# ¹
Computers in Human Behavior	6	Journal of Biomedical Informatics	1
JMIR Serious Games	5	Internet Interventions	1
MIS Quarterly	4	International Journal of Human-Computer Studies	1
Computers & Education	4	International Journal of Medical Informatics	1
Journal of Medical Internet Research	4	Electronic Markets	1
Pharmacy and Therapeutics	2	Health Informatics Journal	1
International Journal of Information Management	2	Translational Behavioral Medicine	1
Communications of the Association for IS	2	Contemporary Educational Psychology	1
Personal and Ubiquitous Computing	2	Colorectal Disease	1
American Medical Association JAMA	1	Hernia	1
Annals of Internal Medicine	1	Information and Software Technology	1
Psychological Bulletin	1	Cyberpsychology & Behavior	1
JAMA Intern Med	1	BMJ Open	1
PLOS Medicine	1	Educational Technology Research and Development	1
Psychological Inquiry	1	American Journal of Health Promotion	1
Neurology	1	Journal of Educational Technology & Society	1
Review of Educational Research Spring	1	BMC Sports Science, Medicine and Rehabilitation	1
British Journal of Dermatology	1	Motivation and Emotion	1
American Psychologist	1	International Journal of Human-Computer Interaction	1
The American Psychologist	1	Human Factors and Ergonomics in Manuf. & Service Ind.	1
Pediatrics	1	Clinical Kinesiology	1
Journal of the Royal Society of Medicine	1	Academic Exchange Quarterly	1
Journal of Marketing Research	1	International Journal of Computer Science in Sport	1
American Journal of Preventive Medicine	1	Int. Journal of Business Science and Applied Manag.	1
JMIR Mhealth Uhealth	1	JMIR Research Protocols	1
Econometrica	1	Journal of Consumer Marketing	1
Journal of Management Information Systems	1	Journal of MUD Research	1
Electronic Commerce Research and Applications	1	The Journal of Marketing Theory and Practice	1
Human Relations	1		

Source: This study. ¹number of papers clustered

Research Topics and Theories

In addition to publication venues, each of the 129 documents was read and classified according to its research topic. After the individual document classification, we classified and colorized their clusters according to the predominant research topic revealed by the documents, unveiling six main research traditions: game-focused literature, gamification design, general empirical gamification, education gamification, healthcare gamification, and individualized gamification (Figure 3).

We also looked for the theories supporting the papers. We identified five theories: Self-determination theory, flow theory, technology acceptance theory, goal-setting theory, and prospect theory. Clusters formed mainly by literature referring to games instead of gamification characterize the beginning of the evolution maps. For this reason, these clusters form the game-focused research tradition. The game-focused literature 2012 cluster, for example, is entirely composed of books that exposed narratives related to games and the potential benefits they could offer to their players (e. g. Gee, 2003; Mcgonigal, 2011). They argue about the believed potential of games in making people feel better and completely changing the world as we know it (Mcgonigal, 2011). Mcgonigal's (2011) book reappears as the central cluster document in the game-focused literature cluster from 2013. This year reveals, however, not only other game-focused literature documents (e.g., Reeves & Read, 2009) but a paper that explored a practical gamified intervention in the education context (Kapp, 2012) and a first reference of the flow theory (Csikszentmihalyi, 1975). We investigated documents citing Csikszentmihalyi's (1975) and his flow theory, and it became possible to identify theoretical developments of his theory. One of them argues that flow is part of a video game mechanism group supporting scientific thinking (Morris *et al.*, 2013). Another proposes a new concept, called gamefulness, and positions it concerning flow theory (Landers *et al.*, 2019). Additionally, a study presents the flow scale-2, investigating a strategy to measure the flow state (Hamari & Koivisto, 2014).

Additionally, 2013 presented the first cluster related to the gamification design research tradition. Gamification design clusters are those in which most documents focus on exploring different strategies to design gamified systems and evaluate their effectiveness (e.g., Deterding *et al.*, 2011b). Still, 2013 is the first year Deterding's (2011a) seminal work conceptualizing gamification appeared in a cluster. It emerged in a coordinated movement characterized by his document increasing its importance and the game-focused literature diminishing its evidence, as it becomes observable from this and following clusters from the evolution map.

In 2014 a single cluster was connected to the research tradition network. It was primarily marked by general empirical gamification studies (e.g., Hamari, Koivisto & Sarsa, 2014) and minorly by context-specific ones. While one of these studies

aimed to gamify learning experiences (Domínguez *et al.*, 2013), others developed research in the healthcare gamification context (King *et al.*, 2013). Clusters of general empirical gamification research tradition empirically investigate, understand, or evaluate gamification effects in a general way, not context or user-type-focused.

Evidence from the evolution map suggests that this movement towards referencing studies that focused on understanding general and specific practical impacts of gamification applications got stronger as documents with such characteristics portray the three clusters generated in 2015. While the smallest cluster relates to general empirical gamification research tradition (e.g., Li, Grossmann & Fitzmaurice, 2012), the other two are context specific. They contain mainly healthcare empirical gamification and game-based studies (e.g., Brach *et al.*, 2012; Kato *et al.*, 2008) and education empirical gamification studies (Domínguez *et al.*, 2013). Still, this late cluster also revealed a high co-citation level of self-determination theory (SDT) related documents (Deci, Koestner & Ryan, 1999). Xu, Buhalis & Weber (2017) applied SDT within the tourism gamification context, and Seaborn & Fels (2015) review recognizes SDT as a fundamental theory within gamification research. Unlike clusters on general empirical gamification research traditions, those related to healthcare and education gamification research traditions are formed mainly by documents aiming to evaluate practical gamified interventions within these specific contexts.

Evidence from the co-citation analysis data suggests that the period between 2015 and 2016 began a movement where healthcare gamification publications significantly started to reference other healthcare gamification documents within their research. Aligned to this interpretation, the 2016 healthcare gamification cluster exposed mainly documents that investigated how gamification could benefit physical activity (e.g., Zuckerman & Gal-Oz, 2014), exercise (e.g., Hamari & Koivisto, 2015), fitness apps (e.g., Chen & Pu, 2014) and cancer pain management (e.g., Stinson, *et al.*, 2013).

This tendency continued in 2017, where the identified healthcare gamification cluster showed mainly documents relating to gamification implications towards health behavior change (Cugelman, 2013), chronic disease management (Miller, Cafazzo & Seto, 2016), and again, exercise (Hamari & Koivisto, 2015).

Alongside the majority of documents related to healthcare gamification (e.g., Johnson *et al.*, 2016; Miller, Cafazzo & Seto, 2016), the healthcare gamification cluster from 2018 is the first in which a few documents are related to different medicine areas (e.g., dealing with diseases like multiple sclerosis (Connor *et al.*, 2014)), and dermatological issues (Hamilton & Brady, 2012)), suggesting that gamification kept evolving as a broad multidisciplinary implementation. Their identification was possible considering their publication journals and that there was no mention of games or gamification within them.

A second cluster also appeared in 2018 and was related to the individualized gamification research tradition. Alike others from this research tradition, this cluster mostly revealed documents focused on the one size does not fit all approach to gamification (Akasaki *et al.*, 2016). This approach focuses on investigating different aspects, such as context, preferences, and characteristics of users, that potentially influence effectiveness levels generated by gamification intervention. Studies from the 2018 individualized gamification cluster investigate, among other questions, how differences in age and motivational effects of the users are related to gamification effectiveness on product advertising (Bittner & Schipper, 2014) and what motivates players to play, specifically investigating how different game types perform within this investigation (Hamari & Keronen, 2017). Lastly, this was the year in which we first observed mention of two theories: goal-setting theory (Landers, Bauer & Callan, 2017) and technology acceptance theory (TAM) (Venkatesh *et al.*, 2003). Rutledge *et al.* (2018) could exemplify research that mentions goal-setting theory. It explores how medical educators could benefit from the relationship between gamification and goal-setting theory.

Additionally, a gamified mHealth solution for behavioral change in persons with multiple sclerosis based on goal-setting theory also was developed (Giunti, Mylonopoulou & Romero, 2018). A study counts on TAM to justify the effects of age on technology adoption and use (Koivisto & Hamari, 2014). Moreover, another study (Burkow *et al.*, 2018) used an application to promote exercise training and physical activity in daily life and tried to use TAM to ground it. However, it was unsuccessful since the theory does not consider group, cultural and social aspects of technology acceptance.

The year 2019 produced three clusters. One still focused on exploring individualized gamification, composed mainly by Hamari & Keronen (2017), lately mentioned research on players' motivation. The other two clusters explored healthcare gamification research but from distinct perspectives. While Patel *et al.* (2017a) cluster evidenced literature mainly focused on investigating gamification interventions to motivate physical activity (e.g., Patel *et al.*, 2017b), Deterding *et al.* (2011a) cluster contains a more heterogeneous group of documents, with a remarkable number of those dedicated to reviewing results from healthcare gamification and game-based interventions (Johnson *et al.*, 2016; Cugelman, 2013). 2019 was also the year where the first co-citations relating to prospect theory were observed (Kahneman & Tversky, 1979). An example is a study that trusted prospect theory to theoretically ground a framework for designing and implementing gameful designs in the transportation context (Yen, Mulley & Burke, 2019).

Nevertheless, data from 2020 was able to generate two new clusters. One of them is mainly composed of research on individualized gamification research tradition, suggesting that the subject is getting more relevant among healthcare gamification researchers. Two examples of documents from this cluster are Buckley & Doyle (2017) and Hanus & Fox (2015). While the first recognizes that individual characteristics impact gamification effects and investigates how different learning

styles and personality traits relate to gamified learning interventions, the second proposes a longitudinal study to test and comprehend the effectiveness of specific game design elements (badges and leaderboards) in the educational context. Indeed, isolating game design elements and understanding their personal effects is a gap to be explored within gamification research (Koivisto & Hamari, 2019), and it seems to be an essential step to implementing individualized gamification effectively.

The second cluster is composed mainly of documents that brought up once again the gamification design research tradition, with some contrasts from the gamification design cluster observed in 2013. Documents in the 2020 cluster propose some revised gamification design frameworks by revealing (Koivisto & Hamari, 2019) and consolidating knowledge accumulated in the last years, while offering future research agenda recommendations.

DISCUSSION

The co-citation analysis results can reveal many aspects of the intellectual structure of healthcare gamification. Table 4 summarizes these aspects.

Table 4: Main aspects revealed by year of analysis.

Year	Main Disclosed Aspects		
	Research Tradition(s) Identified	Documents from the Tradition	Central Tradition Document
2012	Game focused literature	4	Gee, (2003)
2013	Game focused literature	4	McGonigal, (2011)
	Gamification design	10	Deterding <i>et al.</i> , (2011a)
2014	General empirical gamification	17	Deterding <i>et al.</i> , (2011a)
2015	General empirical gamification	2	Li, Grossman & Fitzmaurice (2012)
	Education gamification	16	Dominguez <i>et al.</i> , (2013)
	Healthcare gamification	5	Reeves & Read, (2009)
2016	Healthcare gamification	38	Deterding <i>et al.</i> , (2011a)
2017	Healthcare gamification	16	Deterding <i>et al.</i> , (2011a)
2018	Individualized gamification	2	Chen & Wilkosz, (2014)
	Healthcare gamification	58	Deterding <i>et al.</i> , (2011a)
2019	Individualized gamification	2	Davis (1989)
	Healthcare gamification	20	Deterding <i>et al.</i> , (2011a)
		6	Patel <i>et al.</i> , (2017a)
2020	Individualized gamification	6	Buckley & Doyle, (2017)
	Gamification design	22	Deterding <i>et al.</i> , (2011a)

Source: This study.

Considering co-cited documents, Deterding *et al.*, (2011a) assume a notorious position as a central document for 7 of 16 connected clusters. Indeed, this document offers ideal information for authors to cite, allowing it to assume the central position evidenced by our analysis: it offers the most widespread gamification definition (Mora *et al.*, 2015). Other definitions are still verifiable within the co-citation network, as Huotari & Hamari's (2012) proposition observed within 5 clusters. However, none had the co-citation level reached by Deterding *et al.* (2011a), which is also the definition adopted by this research proposal.

Additionally, the continuous citation of Deterding *et al.* (2011a) over the analyzed periods and across different theoretical traditions is another piece of evidence of its relevance to healthcare gamification research. Looking over the primary documents of the 16 clusters, Deterding appeared in 2013 in the gamification design cluster, followed by the 2014 general empirical gamification cluster, from 2016 to 2019 in healthcare gamification classified clusters, and lastly, in the 2020 gamification design cluster.

The second most co-cited document across the analyzed periods was McGonigal's (2011) book, with five appearances in 2 different research traditions. We first observed the game designer book in the 2013 game-focused literature cluster. We also visualized it as providing a supporting role in the 2014 general empirical gamification cluster and the 2015, 2016, and 2017 healthcare gamification clusters.

These verifications appear as an additional conclusion to the analysis built to reveal central research articles within the gamification healthcare domain (Schmidt-Kraepelin *et al.*, 2018). At that point, authors had evidenced the singular Deterding *et al.*, (2011a) influence on the field, alongside other documents that also appeared within this research (e.g., Hamari, Koivisto & Sarsa., 2014; Cugelman, 2013; Koivisto & Hamari, 2014), but had not mentioned Mcgonigal (2011) book.

Based on the publication venues, the analysis revealed that cited documents are published as journal papers (61%), event papers (24%), books (14%), and one magazine paper (1%). Journal papers, specifically, draw some attention. While we observed some documents published in recognized IS journals, like those presented in the senior basket of 8 (AIS, 2011) and the SIGs journals list (AIS, 2011), a considerable number of documents were published in journals outside these lists, such as JMIR Serious Games (5 documents), Computers & Education (4 documents), Pharmacy and Therapeutics, International Journal of Information Management, Personal and Ubiquitous Computing, and Communications of the Association for Information Systems (2 documents each). This evidence may suggest that healthcare gamification literature can be found not only within the traditionally recognized IS reference journals list but in other journals, mainly from medicine and correlated areas, such as psychology.

Lately, within the analyzed database, five theories were found to mainly support healthcare gamification research: flow theory (Csikszentmihalyi, 1975), self-determination theory (Deci, 1971), technology acceptance theory (Davis, 1989), goal-setting theory (Locke, 1968) and prospect theory (Kahneman & Tversky, 1979). Even though these theories were responsible for bringing healthcare gamification research to the actual development level, literature (Putz & Treiblmaier, 2015) points out some opportunities for theorization with the potential to be explored. These opportunities cover, among others, the social cognitive theory (Bandura, 1986), self-efficacy theory (Bandura, 1977), and cognitive absorption theory (Agarwal & Karahanna, 2000).

Research Opportunities

Both the process of conducting and the conclusions originated from this research revealed some opportunities that future researchers in new studies could take:

1. Using the bibliographical coupling technique to reveal references and similarities among different healthcare gamification areas: As co-citation, the bibliographical coupling is a bibliometric technique used to analyze literature. Bibliographical coupling measures the similarity shared between groups of documents by comparing references (Zupic & Čater, 2015). Compared to co-citation, a variable measure that changes over time according to the most referenced documents, bibliographical coupling does not change since it is calculated based on each document reference list. As much as bibliographical coupling is a technique a decade older than co-citation, science mapping more frequently adopts the latter (Zupic & Čater, 2015). Additionally, none of the literature reviews analyzed during the development of our study has considered adopting bibliographical coupling over healthcare gamification.
2. Adopting new, underdeveloped theories to explore its relations to healthcare game design elements: As mentioned, healthcare gamification research has a limited group of theories more commonly adopted: flow theory (Csikszentmihalyi, 1975), self-determination theory (Deci, 1971), technology acceptance theory (Davis, 1989), goal-setting theory (Locke, 1968) and prospect theory (Kahneman & Tversky, 1979).

Putz & Treiblmaier (2015) highlight eleven theories to expand future gamification research. Their suggestion is corroborated by evidence clustered within the co-citation analysis from our literature review. Looking for promising theoretical options to expand the number of theories applied within the gamification research field, we found studies on the cognitive absorption theory. It was a potential option for expanding the gamification research theory canon (Putz & Treiblmaier, 2015). As conceptualized initially by its creators, cognitive absorption is "a state of deep involvement with software that is exhibited through five dimensions: temporal dissociation, focused immersion, heightened enjoyment, control and curiosity" (Agarwal & Karahanna, 2000:673). A gamification theory-based research agenda created by an expert panel indicated that cognitive absorption theory, as well as investigations towards how gamification interventions help to increase cognitive absorption state, is a promising research option (Putz & Treiblmaier, 2015).

3. Continue to investigate the individualized gamification research tradition emerging within healthcare gamification: Even though results lean to be positive, there are still many mixed results when applying gamification to IS (Koivisto & Hamari, 2019). The reality within healthcare gamification research is not different, with plentiful studies obtaining neutral or mixed effects (Johnson *et al.*, 2016).

Poor game design is one of the critical causes of these results, leading to gamified projects that do not fully consider their users' personal needs and fail to fulfill individual preferences through suitable game design elements (Schöbel & Janson, 2018). Indeed, as evidenced by central literature identified from the co-citation analysis developed within our literature review, understanding how individual preferences may impact gamified experiences is valuable knowledge that can better inform gamified system designers in their work (Buckley & Doyle, 2017). Results found within this study indicate that the individualized gamification research tradition seemed to get more evidence in the last few years.

Studies that follow this research tradition, adopting an individualized gamification approach to better comprehend gamification effects on users, may find fruitful terrain to explore.

4. Investigating different types of game elements: Literature points out that "in terms of understanding how gamification works, we are now seeing studies isolating individual design elements, building on theories to derive and test hypotheses" (Nacke & Deterding, 2017:3). Evidence points towards that it usually counts only on points, badges and leaderboards (PBL) as the most common game elements to implement gamified interventions (Koivisto & Hamari, 2019). Nonetheless, literature within the personalized gamification clusters generated from our literature review suggests that gamification research field studies often do not implement controls over the game design elements applied within their gamification interventions (Koivisto & Hamari, 2019). This lack of controls leads to examining results as a whole and not individually, making it impossible to identify which game design element generated specific observed effects (Koivisto & Hamari, 2019). Examples of these situations can be found within Koivisto & Hamari's (2019) review of 66 gamification-controlled experimental studies, in which only 11 studies individually examined game elements.

This study has some limitations. This research is mainly related to the healthcare gamification research context, so we do not aim to generalize findings to a broader gamification research approach. The limitations of our study include the literature review design specific parameters (such as specific databases, algorithms, and thresholds, as co-citation minimum inclusion values). A critical criterion to determine the literature analyzed in our study was the number of citations, which determined which documents were included in specific quartiles, and, consequently, those that were considered and not considered for analysis. We expected that different combinations of such parameters might lead to slightly different results over the same research question.

CONCLUSION

The primary goal of this research was to answer the question: How has the healthcare gamification literature evolved over the years? To achieve this goal, we designed a science map strategy associated with bibliometric methods over a 520-document database.

Research discoveries originating from co-citation analysis strategies lay around unveiling through nine one-year periods ranging from 2012 to 2020 numerous aspects: research traditions, who were the most co-cited authors, and in which publications venues their research was placed over these periods. Additionally, the documents that represent these research traditions were analyzed and depicted. Still, we identified some theories referenced by healthcare gamification research within the database.

Methodologically speaking, the science map strategy demonstrated a suitable way of revealing the healthcare gamification InS. Generated results suggest that healthcare gamification research is a still-evolving research field, with potential research gaps ready for exploration.

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