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Two decades of game concepts in digital learning environments – A bibliometric study and research agenda

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ABSTRACT

In recent years, using game concepts for educational purposes in digital environments has become continually more popular and relevant. Games can be used to motivate and engage users in regular system use and, in the end, support learners in achieving better learning outcomes. In this context, different kinds of game concepts exist, such as gamification or serious games, each with a different perspective and usefulness in digital learning environments. Because developing and using with game concepts in digital learning environments has recently become more important, and developing them is still not fully established, questions arise about future research directions involving games in digital learning. Therefore, this study aims to identify the state of the field and determine what is relevant when using game concepts in digital learning. To achieve this goal, we present the results of a bibliometric analysis considering more than 10,000 articles between 2000 and 2019 and summarize them to develop a research agenda. This agenda supports researchers and practitioners in identifying avenues for future research. We contribute to theory by providing a detailed understanding of the relevance of game concepts in digital learning. We propose a research agenda to assist researchers in planning future approaches with and about gamification concepts in digital learning. Practical implications are proposed by demonstrating what should be considered when using game concepts in learning environments.

1. Introduction

Gaming is a ubiquitous part of everyday life (Huizinga, 1949). Using game concepts has increased at an astounding pace and has inspired trends, such as gamification and serious games (Hamari et al., 2016; Wouters, van Nimwegen, van Oostendorp, & Van Der Spek, 2013). As game concepts have gained popularity, various well-established research fields have been using with games, including human-computer interaction, information systems, and psychology (Burgers, Eden, van Engelenburg, & Buningh, 2015; Hamari & Koivisto, 2015; Seaborn & Fels, 2015). Considering concepts from games is especially relevant for the digital learning domain, which has received recognition from a multitude of high-impact publications and gained importance over the last decade (Cruz, Hanus, & Fox, 2017; Liu, Li, & Santhanam, 2013; Mekler, Brühlmann, Tuch, & Opwis, 2017; Santhanam, Liu, & Milton-Shen, 2016). In digital

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learning environments, learners must self-regulate and monitor their own learning process (Wong, Khalil, Baars, Koning, & Paas, 2019). The notion in this context is that game elements in digital learning support learners in engaging in their learning activities on a more regular basis (Domínguez et al., 2013) in order to ultimately achieve higher learning outcomes.

The use and effects of using games in digital learning have been extensively discussed in, for example, published meta-analyses (Bai, Hew, & Huang, 2020; Putz, Hofbauer, & Treiblmaier, 2020; Zainuddin, Chu, Shujahat, & Perera, 2020). Nonetheless, questions arise about what to consider in future research to better understand how we can work with game concepts in digital learning to make them more effective (Super, Keller, Betts, & Roach Humphreys, 2019). Discussing and debating research that considers games has changed our perspective, allowing us to think in more detail about the effectiveness of game concepts, gaining a deeper understanding of how game concepts trigger engagement and evaluating if and how we can make game concepts more intelligent (Hamari et al., 2016; Schöbel et al., 2020). The volume of research on game concepts illustrates new trends and developments in design and game concepts in digital learning, especially in how learners differ in their competitive behavior or in their goal orientation (Santhanam et al., 2016; Super et al., 2019), underscoring the need for a comprehensive analysis of past research efforts leading to an overview of future research directions.

The goal of our study is to provide an overview of the current state of the field of game concepts in digital learning to provide future research directions. To summarize the results of existing research and provide an overview of how this research area has developed so far, most studies refer to literature reviews, generic and scoping reviews, or meta-analyses (Chen, Shih, & Law, 2020; Gao, Li, & Sun, 2020; Liu, Moon, Kim, & Dai, 2020). Typically, reviews focus on a limited and analyzable number of studies, and meta-analyses discuss the effects of specific variables on an outcome of interest. Bibliometric studies complement these insights by enabling a holistic synthesis of research streams and describing the distribution of patterns of research articles on a given topic over a given period, thus also being able to identify trends for emerging and future research areas. In our study, we focus on the following research questions (RQ):

RQ1: Which are the most relevant and cited journals and publications relating to game concepts in digital learning that provide a starting point in identifying high-impact research in the field?

RQ2: What are the major research streams of game concepts in digital learning literature?

RQ3: Which directions for future research can be offered to researchers to further explore the field of game concepts in digital learning?

To answer our research questions, we consider research studies from nearly two decades and present a detailed keyword analysis and research agenda for future research projects, highlighting current developments and trends concerning game concepts in digital learning environments. We contribute to theory by presenting a summarized overview of the existing research on game concepts in digital learning. We develop an agenda to assist researchers in aligning and exploring the future of game concepts in digital education. We further contribute to theory by providing an overview of the development of different keyword clusters to understand where research involving game concepts is heading in digital learning, enabling us to explore the concepts in more detail and with a different level of understanding. With this study, we support practitioners and provide implications for how to use game concepts in digital learning environments.

2. Theoretical background

2.1. Game concepts in digital learning

Generally speaking, we use games for fun and entertainment (Werbach & Hunter, 2012). Games today are an essential part of everyday life (Lamb, Annetta, Firestone, & Etopio, 2018). The way we think about games reflects the status games have in society, meaning that they are included in daily life, but more as a secondary activity. Therefore, people do not pay much attention to the actual significance of this concept and its impact on other areas of life, for example, economics and psychology.

Due to the effectiveness of games in our private lives, the concept has been transferred to other parts of our lives, such as work and digital learning. To better understand how we can transfer games to a serious context, such as digital learning, research typically relies on two dimensions: gaming versus playing and parts versus the whole (Deterding, Dixon, Khaled, & Nacke, 2011a). Fig. 1 visualizes the

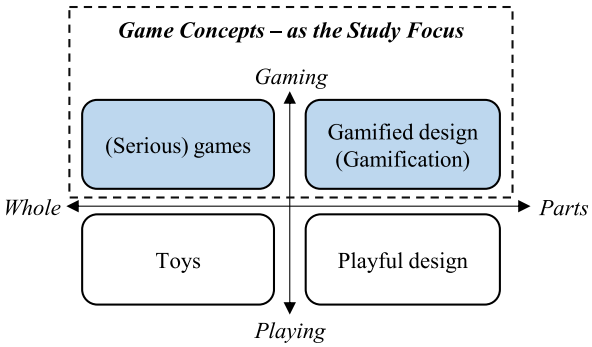

Fig. 1. Focus of this study based on Deterding et al. (2011a)

four classes of games and highlights the focus of the present study.

In this study, we focus on game concepts (upper part of Fig. 1) while considering both the whole of game concepts as well as their parts. We neglect playing (lower part) as something done just for fun, therefore falling beyond the scope of more serious contexts such as learning and education, and focus on game concepts, namely serious games and gamification. These major concepts consider the parts of gaming or the whole, that is, determining if only game elements are considered in a given context or if a complete game world is used for a purpose. In considering the latter—a whole game that has more deliberate context—we refer to the concept of serious games. A serious game can be defined as a "mental contest, played with a computer in accordance with specific rules, that uses entertainment to further government or corporate training, education, health, public policy, and strategic communication objectives" (Zyda, 2005, p. 26). Serious games are those in which the primary goal is education rather than entertainment (Landers, 2015). In contrast, gamification (in other words, a game-like design) refers to single parts of a game that are used in a gaming context. Deterding, Dixon, Khaled, and Nacke (2011a) define gamification as an informal umbrella term for the use of video game elements in non-gaming systems to improve user experience and user engagement (Deterding, Sicart, et al., 2011b). In gamification research, game elements can be described and categorized using the mechanics, dynamics, and aesthetics (MDA) framework, which suggests categorizing game elements into mechanics, dynamics, and aesthetics (Hunicke, LeBlanc, & Zubek, 2004). Mechanics are the functioning components of the game; dynamics, on the other hand, are described as the user's interactions with those mechanics; and aesthetics are characterized as the emotional triggers felt by the player during the interaction in a given context (Hunicke et al., 2004). To sum up, we therefore consider both serious games and gamification in our study and will refer to them as game concepts, defined as "concepts that are used in digital environments and that consider parts of a game or a whole game in non-gaming contexts," throughout the paper.

2.2. The relevance of game concepts in digital learning and avenues for future research

The relevance of game concepts derives from its purpose. Game concepts in digital learning are used to make learning more engaging and more effective, promising better learning outcomes through engaging and motivating learning processes (Christy & Fox, 2014). Toward those ends, learning with games has two purposes (Ibánez, Di-Serio, & Delgado-): first to encourage desired learning behavior, and second, to engage users in learning through the use of materials and methods (tutorials, quizzes, videos, or other digital documents) presented in digital learning environments (Bedwell, Pavlas, Heyne, ; Davis & Singh, 2015; De-Marcos, Garcia-Lopez, & Garcia-Cabot, 2016; Hanus & Fox, 2015). Game concepts can support learners in recognizing that learning can be fun and entertaining, which can stimulate them to perform better (Sailer & Homner, 2019).

To evaluate the effectiveness of game concepts in digital learning, research often relies on experiments or surveys (Hanus & Fox, 2015; Katsaliaki, 2013). To summarize and assess how the use of game concepts in digital learning has developed over time and to identify avenues for future research, previous studies have typically relied on literature reviews, meta-analyses, or bibliometric approaches. Although literature reviews are an important instrument for summarizing existing literature, they are often limited by the number of studies they comprise. Studies that provide a broader perspective on the development of topics follow a meta-analytic or bibliometric approach. Both incorporate the use of statistical methods but with different aims. While meta-analytic approaches focus on highlighting the strength (or absence) of effects of independent on dependent variables, bibliometric studies have become a popular approach to discover patterns in collected knowledge and work that reveal emerging trends in research as it evolves (Trinidad, Ruiz, & Calderón, 2021). We summarize the insights from a selected number of game concept studies in digital learning, that used a literature review, meta-analysis or bibliometric approach in Appendix A.

Meta-analyses summarize existing research and help formulate conclusions about the effects of an independent variable on a determined outcome variable. Consequently, they are supportive of better understanding an individual phenomenon of interest, but they are limited if the intent is to gain a broader perspective on how research involving game concepts in digital learning has developed over time. Nonetheless, they can help us refine our focus for future studies. Thus, meta-analyses related to game concept research in digital learning call for a long-term analysis and more meticulous database research (Chian-Wen, 2014; Lamb et al., 2018), which we address with a bibliometric study. Such research also broadens the perspective on game concepts in digital learning by considering not only gamification but also serious games (Martí-Parreño, Méndez-Ibáñez, & Alonso-Arroyo, 2016). In line with recommendations in existing bibliometric studies that focus on this topic, future research is suggested that considers a longer period and that includes proceedings along with journal publications (Martí-Parreño et al., 2016; Trinidad et al., 2021). Additionally, other bibliometric studies of learning contexts concentrate on the most prominent authors and sources in their work (Karakus, Ersozlu, & Clark, 2019). To identify avenues for future research, bibliometric methodologies provide powerful tools, such as examining the metadata of research papers, especially their keywords. Keywords provide more details about the development of any topic of interest, revealing more about which kinds of outcomes have been analyzed in research. Studies conducted for a specific concept, for example gamification, without a contextual framework, in this case learning, highlight the importance of games in education, calling for a more detailed analysis of game concepts in digital learning (Trinidad et al., 2021).

In conclusion, this study acknowledges the recommendations of existing research and adopts a bibliometric approach to present a holistic synthesis of research streams involving game concepts in digital learning to derive an agenda for future research avenues.

3. Methodology

The decision to rely on a bibliometric method is based on several factors. In general, bibliometric methods are concerned with the study of scientific documents, authors, and publication venues. Bibliometrics have grown beyond frequency analysis and citation counts to include a wide range of methods and techniques that incorporate, for example, network analysis, machine learning, advanced

visualizations, and text mining. They allow the study of a large number of articles. Similarly, bibliometrics can help map numerous authors and their impact, country, or institution (Abramo, D'Angelo, & Di Costa, 2011). The analysis of data was performed with R! Programming language using the Bibliometrix library (Aria & Cuccurullo, 2017). The search was conducted on the ISI Web of Science (WoS) database on April 6, 2020, using the search terms "game" OR "games" OR "gaming" OR "gamification" for all articles published between 2000 and 2019, inclusive. It was performed in education and education-related research areas in the WoS database. The ISI WoS offered a broad collection of articles, ensuring that all published articles were of good quality, and is a robust database. To ensure that the results returned were all relevant, we included other sources[1] not included in the education collection on the WoS for several important reasons: First and foremost, the field of educational technology at the intersection of game concepts is rather interdisciplinary, for instance, as shown through seminal papers on gamification (Deterding, Dixon, et al., 2011a; Hamari, Koivisto, & Sarsa, 2014). Therefore, we included other relevant sources not covered by the initial WoS search, such as those from the information systems discipline, because we were analyzing game concepts in digital learning (Santhanam et al., 2016). Here, interdisciplinary sources provided extensive contributions to the fields of researching digital environments, as recommended by other studies (Wu, Hsiao, Wu, Lin, & Huang, 2012). By expanding our search, we uncovered more reliable results (as also shown in other bibliometric studies on gamification in general; see Martí-Parreño et al. (2016). Second, by widening the scope to include major conferences explicitly, especially those at the intersection of information systems, and computer sciences, we expected to cover a broad range of recent research, as suggested by vom Brocke et al. (2015). Third, we included an open search (similar to the logic of a backward search, e.g. Webster and Watson (2002)) to identify relevant sources that discuss game concept in educational contexts.

All articles matching the following inclusion criteria were included in the study:

- An empirical article matching the search keywords and time span
- A peer-reviewed original article (journal articles and conference papers)
- An article published in English to enable keyword comparison

Articles that did not match all the inclusion criteria were excluded, as were these types of publication: book chapter, letter to the editor, editorial, and news documents. Articles containing the keywords "sport*" OR "physical educat*" OR athleti* OR "train*" were manually inspected by reading the abstracts, and articles unrelated to digital game concepts were excluded. In the case of papers without abstracts or with abstracts lacking clarity, we screened the full texts. The initial search yielded 11,528 records. After removing the sports-related keywords and two duplicate records, four review articles and one editorial were excluded. The final number of articles was 10,273.

The data were cleaned, and author names, journals, and conferences with different spellings were checked and fixed. The analysis included descriptive statistics, in which the count of documents, authors, sources, article types, and other statistics were calculated. As "country" is not a standard field in the metadata provided by the WoS database, the country was extracted from the affiliation of the first author. The Collaboration Index (CI) was calculated as the ratio of the sum of the authors of multi-authored articles to total multi-authored articles. Annual growth rate was calculated as the average percentage increase in the number of articles. Citation analysis was performed based on citations provided by WoS at the time of the search. The number of citations was proposed as a measure that reflects the impact of an article, author, or journal, as it is widely recognized as an important metric. However, it should be viewed with caution and consideration—citation count is also used as a basis for other indices to reflect the author's contribution to a field. We calculated the H index and its variants (M index and G index). The H index is a metric that ranks the impact of an author according to the highest number of articles that received h or more citations (Hirsch, 2005). To overcome the shortcomings of author-selected keywords, which may be restricted by number and space and are not well standardized, similar keywords were grouped together, for example, keywords like "game, games"; "coding, programming"; "collaboration, collaborative".

The network of keywords was plotted using a force-directed algorithm. For the readability of relationships and labels, the network's plot was limited to the 30 most frequent keywords. The keywords were clustered into communities using the Louvain modularity algorithm, an algorithm that has been shown to be computationally efficient and provides good quality community detection (Meo, Ferrara, Fiumara, & Provetti, 2011). Keyword communities are designated by unique colors in the network plot. We also calculated centrality measures of the keywords to assess their importance and interconnectedness with other research themes. Degree centrality represents the total number of unique keywords to which a keyword was linked; Eigenvector centrality represents the strength of connectedness of the connected keywords to the target and therefore represents the expressed influence of the keyword beyond immediate connections. H index and diffusion centralities were also calculated, and both were found to reflect the diffusion of the examined phenomena (Liao, Mariani, Medo, Zhang, & Zhou, 2017). The historiography map is a popular method developed by Eugene Garfield to map the chronological direct citation network within a set of papers. The method maps the most relevant papers by ranking

[1] Articles from the following journals and conferences were manually added to the education collection to ensure that the results include all relevant articles: Computers in Human Behavior, Information Systems Research, European Journal of Information Systems, Journal of Management Information Systems, Computers & Education, Information Systems Journal, Modern Language Journal, International Journal of Human–Computer Studies, Simulation & Gaming, Journal of Management Inquiry, Informatics-Basel, Journal of Strategic Information Systems, Media and Communication, Journal of the Association for Information Systems, MIS Quarterly, Consumption Markets & Culture, Journal of Information Technology, International Journal of Game-Based Learning, Games and Culture, Universal Access in the Information ociety, ACM Transactions on Computer–Human Interaction, Human–Computer Interaction, Information Technology & Management, Production Planning & Control, and Proceedings of Information Systems Security.

them according to their citations within the examined dataset, known as the local citation score (LCS), compared to the papers' overall citations, known as the global citation score (GCS). Papers with high local citation scores are more relevant to the examined topic, which is shown on the graph.

The country network of collaboration was created for documents with two or more authors affiliated with different countries. For clarity, the top 30 country networks were represented in the network. To understand the structure of collaborating networks, we applied the Louvain modularity (Meo et al., 2011) for community detection to cluster countries that collaborated frequently. Community detection was also applied to the keyword network to cluster the words that were mentioned together in the same abstracts. Keywords belonging to the same community reflect common research themes. Communities are color-coded in the network plots.

4. Results

4.1. General results

In our study, we present articles published from 2000 to 2019 (see Fig. 2).

Using game concepts in digital learning started early in 2000 when 44 articles were published. Until then, the use of game concepts in learning environments had continuously increased. Aside from 2006 to 2009, the number of published articles increased each year, resulting in the most published articles in 2017, with 1396 articles. After 2017, the number of articles published decreased.[2] Proceedings were increasing much faster than journal publications. Journal publications remained at a similar level from 2015 to 2019.

To answer RQ1, we identified the top sources publishing articles on the use of game concepts in digital learning environments. A summary of the top sources and the citations of each type of publication is given in Table 1. According to the number of publications, the most relevant source was the journal Computers in Human Behavior, in which studies also had a high number of citations. The second source was Computers & Education, which had a lower number of publications but was cited more often than Computers in Human Behavior. Two conferences were named more than once in our top 15 sources: the International Technology, Education, and Development Conference and the European Conference on Game Based Learning. However, we noted that they were not cited as often as the journal sources.

In a more detailed step, we focused on the most cited articles to better understand which topics were relevant for establishing game concepts in digital learning. Therefore, we referred to the top 20 authors' most-cited papers (Table 2). Aside from the study by Hanus & Fox (2015) published in 2015, all others were published between 2000 and 2013. Consequently, we could assume that these studies were the most influential in making game concepts prominent the field of digital learning. Three of our ten most-cited manuscripts focused on gamification. Three other publications worked with serious games, whereas the other four manuscripts focused on games or simulations. Although the four game-related studies claimed to work with games, they introduced serious gaming components. A game is something that is only used to entertain without more serious intentions. Concerning the studies' context, studies that worked with serious games related to middle school (Dunleavy, Dede, & Mitchell, 2009) or elementary school (Barab, Thomas, Dodge, Carteaux, & Tuzun, 2005). Learners from middle and elementary schools seem to learn better and more efficiently when acting in a game-like reality environment. All gamification studies related to a university context, which probably requires a more serious learning environment by referring only to the components of a game.

4.2. Authors and countries

In the next step, we analyzed the most prominent authors and countries (Fig. 3). With 42 publications, Hainey was the most productive author. The author's work focused on reality games (Connolly, Stansfield, & Hainey, 2011), serious gaming (Hainey, Connolly, Stansfield, & Boyle, 2011a; Hainey, Hakulinen, Connolly, Stansfield, & Boyle, 2011b), and animations and simulations (Boyle et al., 2014), with the first publication in 2007. The second most productive author was Connolly. With 36 publications, Hwang was in third position among the most productive authors over time. His first study was published in 2011, and most of his work focused on serious games and on educating students on healthier eating behavior (Sung & Hwang, 2013; Yien, Hung, Hwang, & Lin, 2011). The first study published in 2003 focused on the differences between novices and experts regarding computer games (Hong & Liu, 2003).

Similar to this was the work of Chan, with a total of 26 publications, the first in 2002. Again, the studies' foci were on games and serious games in education, and considered learning preferences and game design in the earliest published study (Chen, Liao, Cheng, Yeh, & Chan, 2012; Yu, Chang, Liu, & Chan, 2002). Finally, the work of Kaufman, with 19 studies, was also about simulations and digital games (Sauvé, Renaud, & Kaufman, 2010, pp. 1–26; Zhang & Kaufman, 2016). However, compared to the other two authors, Kaufman focused not only on younger students but also on older adults (Zhang & Kaufman, 2016).

Next, we analyzed how the studies influenced each other and contributed to the temporal development of the field (Fig. 4).[3]

Early influential studies were authored by de Freitas and Oliver (2006), and Ebner and Holzinger (2007). The work presented by de

[2] The last two years showed a marked drop in proceeding papers but not journal papers, reflecting the slow process of indexing proceeding papers rather than a drop in published articles.

[3] This is only a fraction of prominent authors. Not all authors will show up in the graph. This graph shows authors who are more prominent locally than universally, so those with high impact in technology/education/tech-ed will have little chance of showing up here. In other words, authors with a more global impact (beyond the gaming community) may not show here. Juho Hamari, for example, is a well-known author on gamification (and so far only that); most of Hamari's work was developed after 2015, which is why he does not show up in this graph.

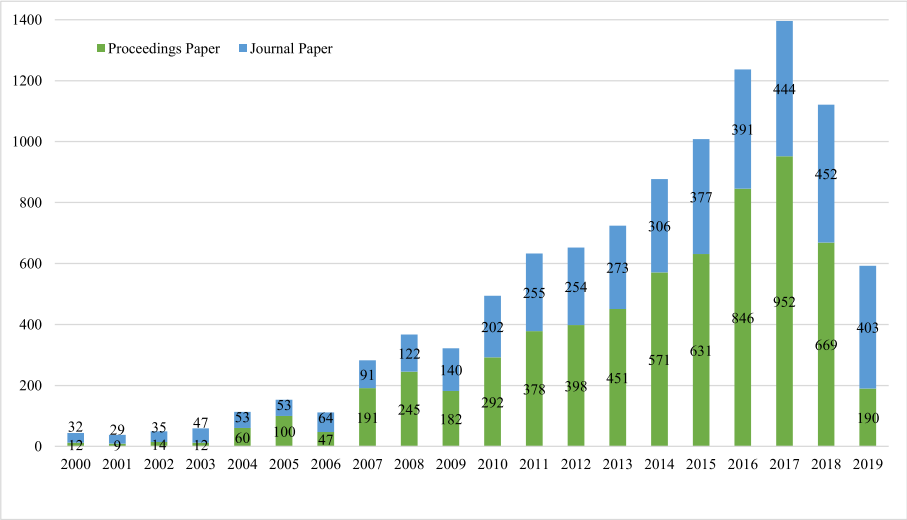

Fig. 2. Articles published by year, differentiated by journal and proceedings.

Table 1
Basic data of analyzed studies.

Source	Number published	Times cited	Percentage of all citations	Citations per article
Computers in Human Behavior	623	14,784	17.16	23.73
Computers and Education	374	17,278	20.05	46.19
British Journal of Educational Technology	134	3580	4.15	26.71
Educational Technology and Society	130	2093	2.42	16.1
9th *International Conference on Education and New Learning Technologies*	129	21	0.02	0.16
10th *European Conference on Games-based Learning*	126	89	0.10	0.70
Journal of Chemical Education	125	803	0.93	6.42
11th *European Conference on Games-based Learning*	123	64	0.078	0.52
12th *European Conference on Games-based Learning*	113	24	0.02	0.21
11th *International Technology, Education and Development Conference*	110	50	0.05	0.45
8th *European Conference on Games-based Learning*	105	191	0.22	1.81
12th *International Technology, Education and Development Conference*	101	12	0.01	0.11
9th *European Conference on Games-based Learning*	101	118	0.13	1.16
International Journal of Engineering Education	96	504	0.58	5.25
5th *European Conference on Games-based Learning*	96	122	0.14	1.27

Table 2
Top-cited manuscripts.

Author	Total Citations	Keywords	Category
Papastergiou (2009)	597	Interactive learning environments, multimedia/hypermedia systems, applications in subject areas, secondary education, gender studies	Serious Games
Dominguez A. (2013)	472	Gamification, game-based learning, computer game, game mechanics, motivation, engagement, e-learning	Gamification
Barab S. (2005)	422	NA	Serious Games
Charlton J.P. (2007)	395	Addiction, attitudes, impulse control disorders, taxonomies, computer games, computer	Games
Dunleavy M. (2009)	355	Augmented reality, immersive participation, simulation, classroom technology practices, handheld devices, GPS devices	Internet Games
de Freitas (2006)	326	Addiction, attitudes, impulse control disorders, taxonomies, computer games, computer	Simulation
Hanus and Fox (2015)	317	Virtual reality, improving classroom teaching, human–computer interface, interactive learning environments, teaching strategies	Gamification
Chou C. (2000)	303	Internet, internet addiction	Games
Ebner M. (2007)	302	Game-based learning, e-learning, human technology interaction, usability, civil engineering, structural concrete, theory of structures	Gamification
Rosas R. (2003)	299	NA	Serious Games

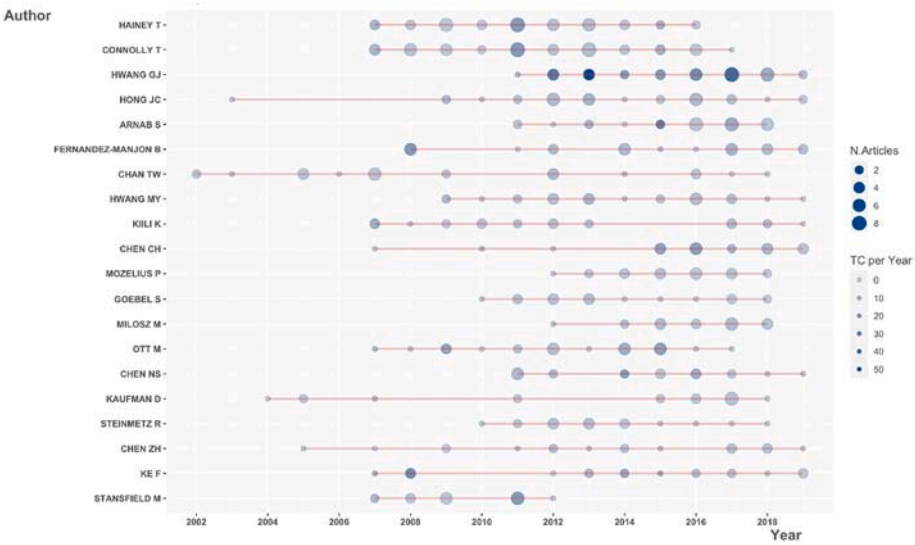

Fig. 3. Top authors' production over time.

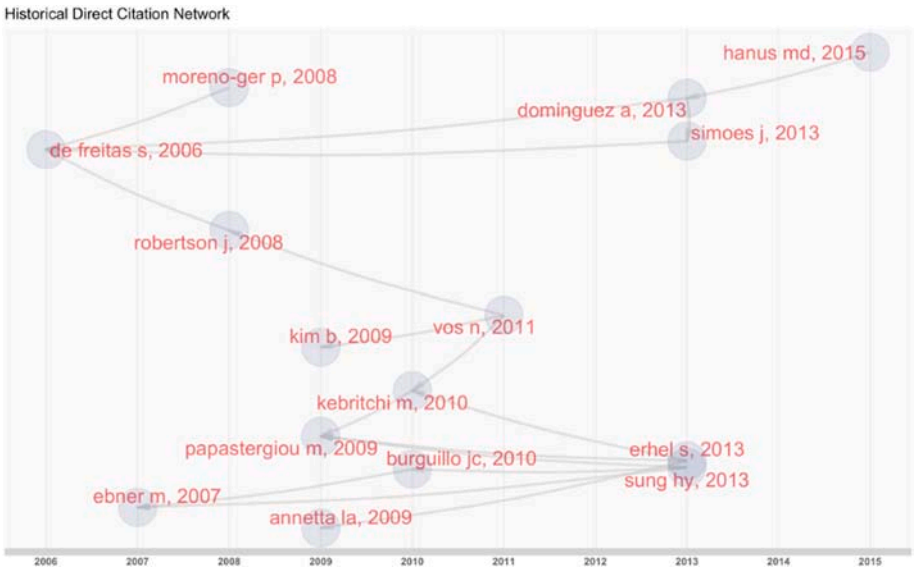

Fig. 4. Historical direct citation network.

Freitas and Oliver (2006) was a kind of "how-to" publication guiding the creation of one's own simulation or serious gaming world. All studies that referred to the work of de Freitas and Oliver (2006), and Ebner and Holzinger (2007) demonstrated gamification research (most presented the results of field experiments exploring the effectiveness of gamification) (Domínguez et al., 2013; Hanus & Fox, 2015; Simoes, DíazRedondo, & FernándezVilas, 2013).

We then analyzed which countries published their work together (Fig. 5).[4] Working with game concepts seems to be important and relevant for many different countries. Our network graph demonstrates that only limited strong relationships exist between countries. Authors from the United States seem to publish their studies more often with authors from China and Canada. Authors from the United Kingdom publish their work with many other countries, including the United States, Spain, Netherlands, Italy, and Australia. Last, German authors published work more often with researchers from Italy. Spain was involved with countries such as the United Kingdom

[4] We applied Louvain modularity for community detection to cluster countries that frequently collaborate. Countries that belong to the same community reflect common collaboration. Communities are color-coded in the network plots.

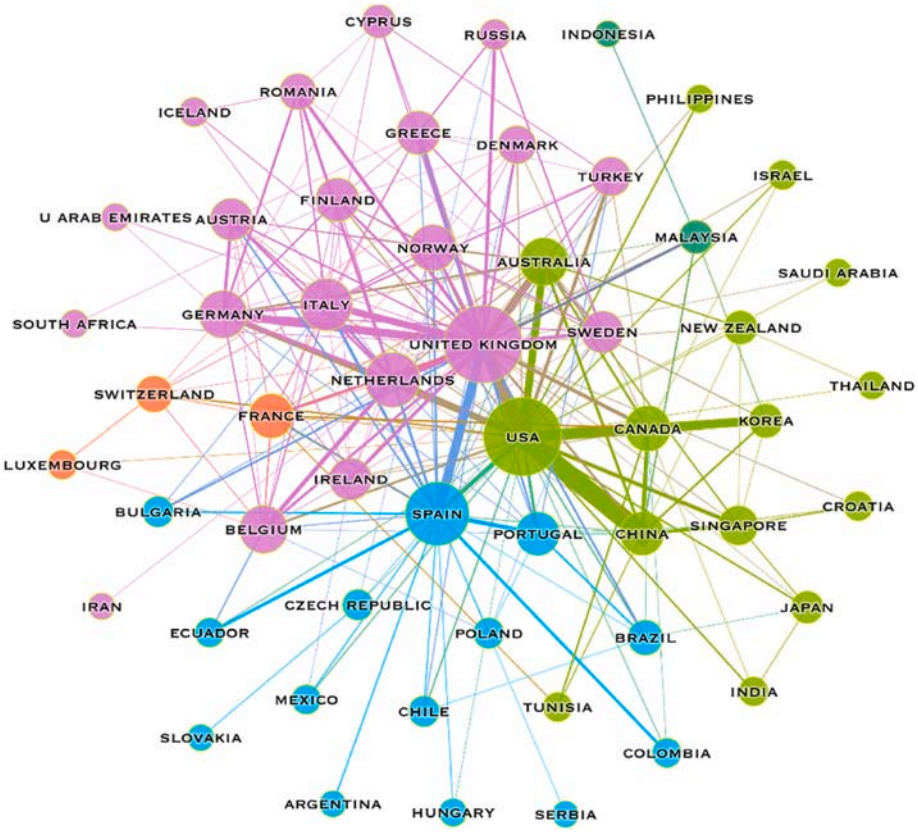

Fig. 5. Countries network.

and the Netherlands. All other countries had fewer publications and were not significantly involved in publishing work with other countries.

Interestingly, although researching game concepts in digital learning seems to be of international (Ernst, Janson, Söllner, & Leimeister, 2016) relevance, cultural adaption of game concepts was not a key component of the studies we analyzed, nor was culture a major part of our keyword analysis.[5] Work by Li and Kirkup (2007) analyzed cultural differences between Chinese and UK students regarding their internet use. However, few studies considering cultural aspects in their research studies discussed the design of game concepts and digital learning solutions in combination with cultural issues.

4.3. General keyword analysis

Table 3 presents the top 20 keywords among all studies and supports us in answering RQ2. A detailed keyword network can be found in *Appendix B*. The keywords most often mentioned focused on the classification of different kinds of games: *games*, *gamification*, and *serious games*. *Games* was by far the most popular keyword, which is easily explained because it is relevant in publications about both serious games and gamification. Using parts of a game seemed to be more popular than implementing a serious game-like world.

Motivation was relevant in considering game concepts in digital learning; it was used 345 times as a keyword, and *collaboration* also seemed to be of importance in digital learning environments. Although the goal of gamification and/or serious games is to support learning, *learning outcomes* was not in the top 20 keywords. Outcomes that were considered were *motivation* and *engagement*. These two are important variables for assessing the effectiveness of a game concept, but they do not necessarily characterize the effectiveness of game concepts in digital learning. The effectiveness of game concepts could be supported by evaluating learning outcomes.

In the next step, we analyzed the yearly growth of our top keywords (Fig. 6). A detailed overview can be found in *Appendix C*. Research involving gamification was first published in 2010 (Bunchball, 2010). From 2011, the frequency increased markedly until 2017, when it began to decline. Other than serious games, *games* was mentioned earlier than *gamification*. Games seem to have been relevant for digital learning since 2001. In 2008, the keyword *game-based learning* decreased to being named less than 50 times and

[5] The keyword "culture" was used in 18 of the publications we analyzed. Similar keywords connected to culture, such as cultural diversity or intercultural education, were used in four or fewer publications.

Table 3
Top 20 keywords.

Position	Keyword	Frequency	Position	Keyword	Frequency
1	Games	1752	11	Virtual Worlds	311
2	Game-based learning	1441	12	Collaboration	272
3	Gamification	760	13	Technology	272
4	Serious Games	671	14	Programming	228
5	Learning	594	15	Game Design	193
6	E-Learning	537	16	Children	190
7	Education	497	17	Engagement	186
8	Stem	360	18	Higher Education	184
9	Motivation	345	19	Assessment	148
10	Simulation	327	20	Evaluation	133

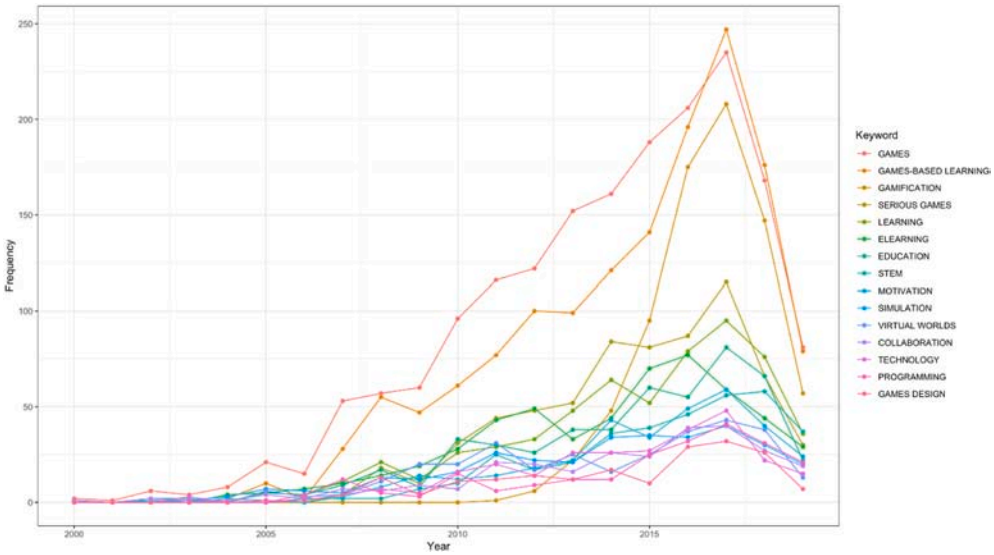

Fig. 6. Yearly growth of the top 15 keywords.

then began to regain its relevance, steadily increasing until 2017. The keywords *collaboration*, *technology*, *programming*, *game design*, *virtual world*, *simulation*, and *motivation* occurred at a lower frequency compared to *games*, *gamification*, *serious games*, *game-based learning*, *learning*, *e-learning*, and *education*.[6] This was very interesting and helpful in terms of identifying other research directions to pursue and supporting the use of game concepts in education and learning.

4.4. Keyword Clustering—A detailed understanding of the development of game concepts

To better understand the relevance of various keywords, we next clustered our keywords to get an idea of how they had developed over time. A definition of each cluster is presented in *Appendix D*. By clustering, we mean that we consolidated keywords that focused on the same issue, such as *motivation* and *intrinsic motivation* or *cooperation* and *collaboration*. We categorized keywords that reflect an outcome variable and keywords that designate a specific device, technology or system. We considered game dynamics (e.g., collaboration and competition) and the kind of elements that were used as keywords—research suggests analyzing individual game elements such as badges in more detail (Seaborn & Fels, 2015). Last, we considered surrounding realities, such as virtual reality or augmented reality, and considered two other keywords that were important to consider for future research—*game design* and *artificial intelligence* (AI).

A summary of the keyword clusters, their frequency, and centrality measures of the keywords are given in Table 4.

The centrality measures of the keywords showed that game, gamification, and learning-related keywords were the most central keywords with the highest influence according to degree, Eigenvector, and H-index centrality. Diffusion centrality was also high but with small differences between these keywords, highlighting the comparable range of spread of these research themes and their close

[6] Note that the decreasing number of publications from 2018 to 2019 does not necessarily indicate that fewer studies were published. This is an artificial effect, as ISI had not published all 2019 conferences and proceedings, causing these low values in the last year.

Table 4
Keyword clustering.

Keyword	Frequency	Degree	Eigenvector	H-Index	Diffusion
Outcomes					
Motivation	1844	384	0.654166018	79	24,251
Performance	1280	290	0.544886025	76	20,180
Engagement	860	259	0.511034186	76	20,295
Flow	471	111	0.272894423	52	11,402
Enjoyment	216	88	0.213309383	46	8934
Cognitive Load	85	39	0.097880221	26	4406
Satisfaction	50	33	0.130779701	25	6468
Learning Environments and Devices					
Simulation	2075	288	0.54041196	74	19,713
Virtual World	1188	213	0.43677801	67	16,754
Mobile	408	139	0.3192302	58	12,781
Active	215	86	0.25809592	45	8715
MOOC	188	68	0.19253663	39	8535
Computer-based	138	57	0.15825591	36	7754
Dynamics					
Collaborative	1712	321	0.58528995	76	21,234
Competition	548	127	0.31744417	61	13,234
Elements					
Avatar	111	24	0.07135122	20	3463
Badges	76	45	0.13817185	34	5768
Technology Trends					
VR	1060	227	0.43173038	65	16,558
AR	505	133	0.30629453	58	12,286
Others					
Game Design	1118	18	0.06367297	15	3149
AI	257	53	0.13700102	34	5875

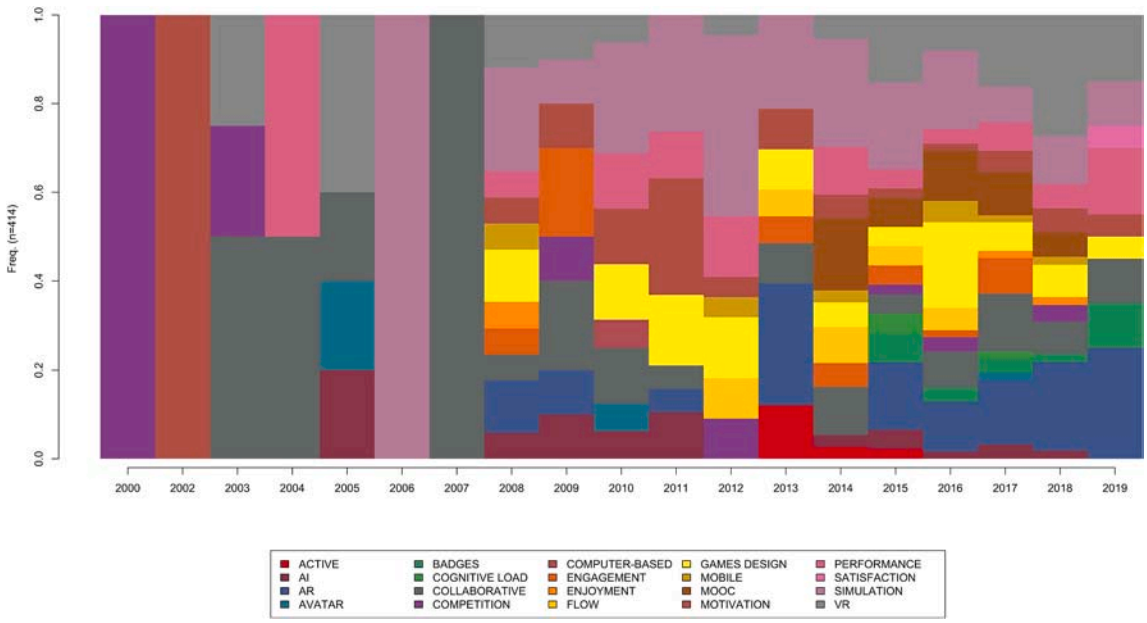

Fig. 7. Keyword development.

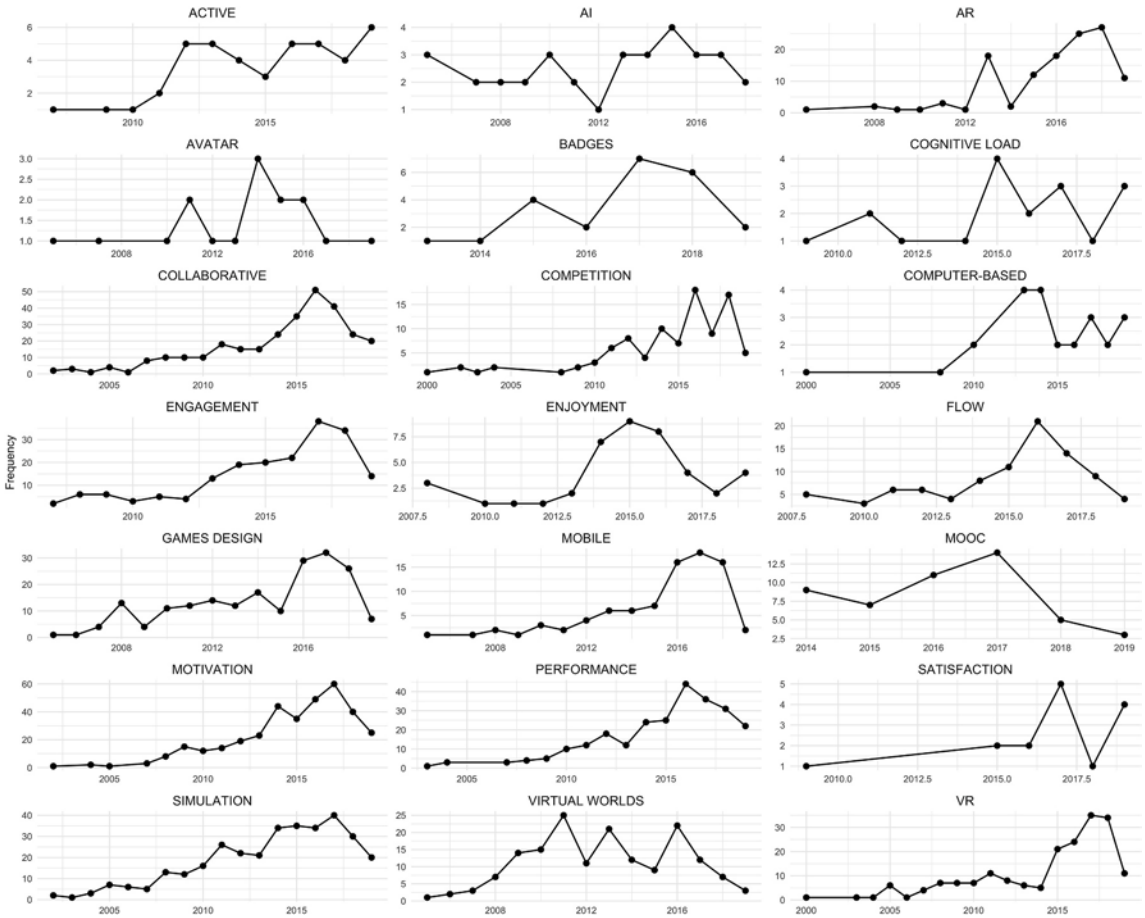

Fig. 8. Individual keyword development.

influence. To further examine the influence and diffusion of our categorized keywords, we calculated the centrality measures for these themed keywords. The keywords *motivation*, *performance*, and *engagement* had very high H-index and diffusion centrality, indicating their strong influence and spread in the reported literature, like *simulation*, *virtual worlds*, and *virtual reality*. The values of diffusion and H-index centralities indicated that these themes were associated with a wide range of applications of games, adoption, and endorsement by diverse game communities.

In general, the outcome keyword most often mentioned was *motivation*, followed by *performance* and *engagement*. Neither *cognitive load* nor *satisfaction* were included often as keywords. Cognitive load theory posits that learners have a working memory with a limited capacity when it comes to dealing with new information (Sweller, 1994) and is discussed extensively when researching digital learning (Janson, Söllner, & Leimeister, 2020) environments (Ayres, 2020; Sweller, 1994). Satisfaction is another important outcome regarding the effectiveness of digital learning (Janson, Söllner, & Leimeister, 2017; Gupta & Bostrom, 2013). The devices most often mentioned were simulations and virtual worlds, which can be explained by the prevalence of serious games and gaming in the studies we analyzed. Mobile learning seemed to be more relevant than computer-based learning and even more relevant than active learning (e.g., in a classroom without technical devices). The dynamic that was referred to most often was collaboration, which is important for learning when it occurs in groups, considering not only the single learner but also a group of learners. *Collaboration* was a keyword more often than *competition* (*collaboration* was used 1712 times and *competition* 548 times). This is supported by other researchers who suggest that competition in learning needs to be further explored to make it more efficient and effective in designing game concepts and game components (Burguillo, 2010; Dissanayake, Mehta, Palvia, Taras, & Amoako-Gyampah, 2019; Santhanam et al., 2016; Scheiner, 2015). The surrounding reality most often used was VR. Creating VR requires a detailed design concept. *Game design* was named as a keyword 1118 times. Game design seems to be more relevant in creating serious games and simulations for which a complete virtual environment must be constructed and single elements are not enough to work with. Surprisingly, AI was referred to

only 257 times. Accordingly, there is still much more to explore about how to construct intelligent and adaptive game designs, regardless of whether we are using game concepts such as serious games or gamification.

Besides analyzing keyword frequency, we were interested in their development over time. Fig. 7 shows the proportion of articles having the given keyword of all articles published at that year. It demonstrates that certain keywords are continuously relevant over time, such as *simulation*, which was first used in keyword combinations in 2006 and remained part of studies till 2018. Interest in AR grew from 2015 to 2018. Discussing and researching game design began in 2008 and was then relevant in more studies throughout that time.

To illustrate a more detailed overview of each of our keywords and its development from 2000 to 2018, we constructed Fig. 8. A consolidated overview about the yearly growth of the keywords can be found in *Appendix E*.

The keyword development of the terms *virtual worlds* and *augmented reality* decreased directly after increasing. Other keywords were just becoming part of research studies, such as *satisfaction*, which was first mentioned in 2014 as a keyword. Similarly, *cognitive load* was not referred to often. It started to appear more often in 2015.

The outcome variable *motivation* steadily increased as a keyword as did *performance*. In contrast, *engagement* as a keyword appeared more often in 2012 and *flow* in 2015. *Satisfaction*, *enjoyment*, and *cognitive load* were listed as keywords more often from 2014 to 2019, but at a lower rate compared to the *motivation* and *performance*. The most relevant environment seemed to be *simulation*, whose growth as a keyword started earlier in 2007. *Computer-based learning* was referred to more often in 2013 and 2014. Comparing the two dynamics, we observed that *collaboration* started to grow in 2009 and grew markedly between 2014 (frequency less than 20) and 2016 (frequency close to 50), whereas in 2014, *competition* started to grow. Both game elements *avatar* and *level* were part of the studies' keywords at a lower level. Both rose in frequency from 2014 on.

VR began to increase in 2011, decreased until 2014, and increased intensively in more recent years. The relevance of AR seemed to decrease and increase more often than we observed for the development of VR. AI seemed more relevant during more recent years, with a higher number of keyword mentions in 2013. The development of our keyword clusters supported us in deriving a research agenda for research on game concepts in digital learning, which we refer to in the following subsection.

4.5. Research agenda

We used our keyword clusters to propose a research agenda for game concepts in digital learning environments to answer RQ3 (Fig. 9).

To derive our agenda, we categorized our clusters into three groups: emerging keywords that were just starting to be explored,

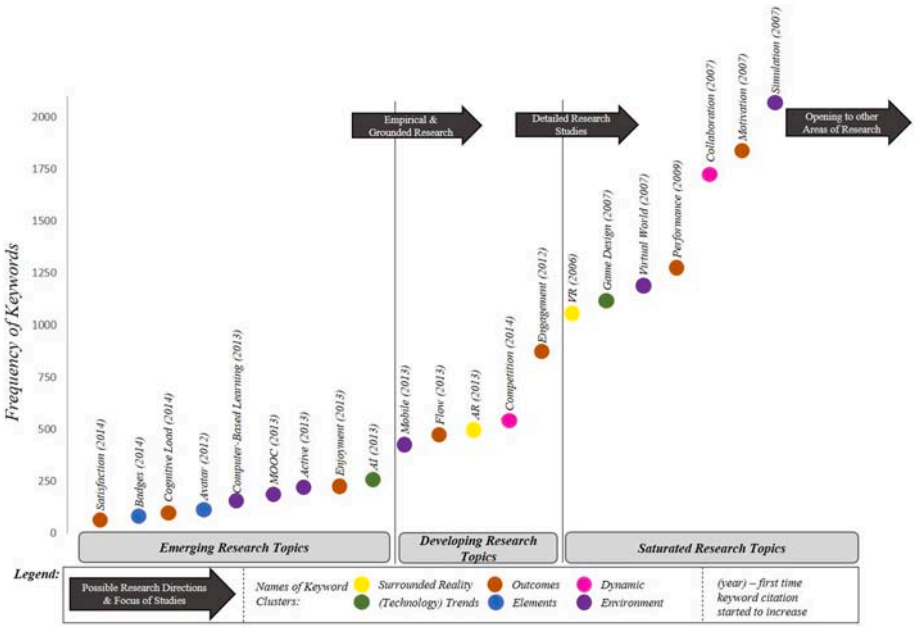

Fig. 9. Suggestion for research agenda.

those with developing research topics considering keywords that had grown over time and that needed more detailed research articles to explore them in more detail, and those with saturated research topics. We will discuss group in more detail, considering the literature that supports the state of each topic.

4.5.1. Emerging research topics

Badges and avatars are among the emerging topics. Other researchers suggest analyzing the effectiveness of individual game elements to be able to understand and adapt their individual designs and to get away from project-based learning (PBL) designs (Schöbel, Janson, & Mishra, 2019; Seaborn & Fels, 2015; Wouters et al., 2013). This holds especially true for gamified learning solutions (Santhanam et al., 2016). In addition, three of our outcome variables were in the first group. Research supports the idea of focusing on specific variables to better understand how game concepts can support digital learning (Chian-Wen, 2014). Cognitive load could be especially important in the future for game worlds, for example, for VR environments that consider complex animations, as they could increase the risk of overwhelming a learner's working memory (Ayres & Paas, 2007). This perspective is supported by several researchers and warrants a more detailed analysis of how games in digital learning affect the reactions of learners due to mixed effects on performance (Sailer & Homner, 2019; Santhanam et al., 2016; Silva, Rodrigues, & Leal, 2020). Long-term effects, especially (e.g. for analyzing motivational effects of gamification), are still to be explored in their effects, for example, on specific outcome variables (Sailer & Homner, 2019).

Three of our environmental keywords are also in the first group. Since most studies on games focus on incorporating computers, a combination of active and computer-based learning could be interesting to explore further. Finally, AI was grouped as an emerging research topic because it has gained relevance over the last few years and enables individualizing game concepts in digital learning (Schöbel et al., 2020). Its relevance to better analyzing individual game concepts comes from observations that the effects on learning outcomes still cannot be fully explained (Super et al., 2019). Learners, especially, differ in their learning behavior and their goals, better known as learner goal orientation (Hakulinen & Auvinen, 2014). This theory clusters learners into performance- and mastery-oriented learners. While one group totally supports competitive learning environments and wants to compete with other learners, the other group is focused on their own individual performance success. Here, the first group could be supported by competitive game elements, whereas the other group would not be motivated by competitive game concepts. However, even when using competitive elements, learners differ in how they experience them and require individualized designs (Santhanam et al., 2016). Such aspects can be approached through AI methods.

4.5.2. Developing research topics

This group of keywords appeared at a higher frequency. All keywords increased in frequency in 2013 and 2014, except *engagement*, which increased in 2012. Engagement is one of the most important constructs related to game concepts; it has been part of many studies and is essential to making game concepts in digital learning effective (Kuo & Chuang, 2016). However, some researchers assert that we still need to determine which constructs surround engagement in order to better understand how it develops (Hamari et al., 2016). Consequently, we support the idea that the keywords in the second group should be considered for detailed research that discusses each topic (keyword) in more depth, taking a closer look at how engagement is induced by game concepts in digital learning. This is similar to observing how flow develops (Suh, Cheung, Ahuja, & Wagner, 2017) and how game concepts can be adapted to make them more useful for mobile phones (Kurniawan, Sitohang, & Rukmono,). Competition is another construct of interest. We understand how we can design and consider competitive game elements; what is still being discussed and analyzed in research and in practice is how we can adapt competition to individual game designs (Santhanam et al., 2016). Ultimately, AR was categorized as a developing research topic.

4.5.3. Saturated research topics

The third group of keywords comprises saturated research topics and is the high frequency group. This frequency continuously increased in 2006, 2007, and 2009. The keywords we considered have been extensively discussed in previous research, such as *collaboration* or *simulations*, which have long been a part of serious games for learning and online education. It may be worthwhile to think about how to connect these keywords to other areas of research or how to make them more applicable to increase the number of keywords. Here, we can refer to methods of AI to consider adaptive and intelligent VR solutions for collaborative learning experiences. Game design has been part of most serious gaming environments, but it has also become more important for gamification designs to enable designers to construct, for example, more user-centered and meaningful game concepts (Hallifax, Serna, Marty, Lavoué, & Lavou). Performance is especially worth considering when looking at the long-term effects of operating with game concepts, which have recently become more important for research (Ahmad et al., 2020). Analyzing long-term effects would lead to other contributions and a deeper understanding of what matters in digital learning in the long run. Additionally, the positive and negative effects of game concepts on outcomes are worth comparing to offer verifiable evidence (Trinidad et al., 2021) or to concentrate on effective outcomes (Chian-Wen, 2014). This also holds true for motivation. Although we know that there are motivating effects when we work with game concepts, it is still important to analyze and discuss how different kinds of motivations are guided by game concepts, by explaining, for instance, how intrinsic motivating effects differ from extrinsic effects in terms of the elements involved (Sailer & Homner, 2019).

With our research agenda in mind, we next discuss our results and posit the potential contributions, limitations, and implications for future research.

5. Discussion and contributions

The results of our bibliometric analysis provide information on the most cited publications in journals as well as conferences (RQ1). Game concepts in digital learning have not only been a part of conference publications but have also been extensively discussed in journal articles. Our results highlight that different types of game concepts (e.g., gamification, serious games, etc.) have been considered equally in research studies to date. While gamification and serious games both work with game elements, they differ regarding how these elements are embedded—either in a simulated world or in a regular system involving only some game elements without presenting a virtual world (Werbach & Hunter, 2012). Because both gamification and serious games seem to be equally important, we can guess that they provide a useful concept for motivating learners in digital learning environments. Both journals—Computers in Human Behavior and Computers and Education—make a significant contribution, highlighting that game concepts in digital learning have their origins at the interdisciplinary intersection of psychology and educational technology. The general statistics in our bibliometric study demonstrate that game concepts in digital learning are of international relevance, supporting the idea that concepts such as gamification or serious games can be culturally adapted. Furthermore, using games involves not only the concepts of serious gaming and simulation; also relevant is the concept of gamification. However, we observed that each concept faces different challenges. Gamification research, for example, calls for a more in-depth analysis of specific elements, whereas examining serious games requires considering game design in more detail (Seaborn & Fels, 2015).

To answer RQ2, we need to learn more about the most important research streams in relation to game concepts in digital learning. To better understand which streams of research exist, we clustered the keywords we identified into six groups. A group of keywords that have not yet been listed often are those relating to outcomes—*satisfaction*, *cognitive load*, *enjoyment*, or *motivation* and *performance*. Research shows that the effects of establishing game concepts in digital learning deliver mixed results regarding learner performance (Sailer & Homner, 2019; Seaborn & Fels, 2015). Consequently, to better understand how performance is influenced by game concepts, it could also be helpful to analyze constructs surrounding learning performance from a long-term perspective (Silva et al., 2020). Our clustering of technology trends supports the idea that AI could be a promising new approach to better individualize game concepts in digital learning and to allow for greater personalization (Trinidad et al., 2021). Another cluster that requires more in-depth understanding is the cluster of elements (e.g., badges and avatars). Referring to the two game dynamics we identified, more could be learned about the effectiveness of competition (Santhanam et al., 2016).

The aim of RQ3 was to identify streams for future research. We identified three research directions that demand different kinds of research studies. Regarding the group of emerging research topics, we observed that for some constructs, we still need to determine how they are formed in relation to using games and game-like elements in online learning environments (Hamari et al., 2016). Constructs like satisfaction or cognitive load, especially, could be explored in more detail when implementing game concepts. (Sailer, Hense, Mayr, &). One interesting observation regarding emerging research areas was that AI and VR were in the most cited manuscripts. Game concepts in digital learning seem to be important in relation to specific devices, making a game more realistic and fun to facilitate better learning processes through customized game-based learning interventions (Rowe, Shores, Mott, & Lester, 2011; Schöbel et al., 2020). Such customization could happen by referring to AI. Regarding our second research cluster, topics such as AR, flow, and competition should be examined in more detail in future research, with special consideration given to empirical analyses. With regard to saturated research topics, it could be worthwhile to consider rethinking the concepts of game design in digital learning. Keywords such as *collaboration* are well-known in research on digital learning. For this group of keywords, researchers could discuss how to further explore them from another perspective.

Changing the perspective on a group of keywords also implies changing how we think about game concepts. Designing a game concept entails making a gaming experience meaningful to users. Design was part of our keyword analysis, which indicated that it is most relevant for serious games. However, game design is becoming more important for gamified solutions, such as through the use of functional affordances (Lowry, Petter, & Leimeister, 2020; Schöbel et al., 2020). Our analysis also indicated that different constructs and variables matter in designing gamification concepts in digital learning. For those groups of keywords especially, it could be worthwhile to change our perspective on them. For example, *motivation* was among the keywords we grouped as saturated research topics. When operating and analyzing the motivational effects of gamification concepts, most studies refer to self-determination theory (Deci et al., 2001). However, in looking at recommendations given in the research, we should be more open-minded towards new and alternative theories to bring concepts such as gamification to the next level of development (Lowry et al., 2020) and change the perspective on specific outcomes like motivation. Furthermore, it may be worth stepping away from standardized game elements and thinking about new elements and combinations of elements (Trinidad et al., 2021).

Our study contributes to theory and practice. From a theoretical perspective, we provide clarification on topics related to game concepts in digital learning. In our research, we present a summarized overview of existing research on game concepts in digital

learning to enable researchers to identify new areas for future research projects. By differentiating our keywords into clusters, we provide precise implications for future research on different concepts and game-related outcomes. From our analysis, researchers can conduct more specialized analyses by conducting, for example, follow up meta-analyses with specific keywords to discuss the relevance and impact of gamified AI solutions in digital learning or by analyzing the role of satisfaction in more detail. Therefore, we contribute to a better understanding of the relevant key terms and support practitioners by highlighting which topics and areas are relevant for game concepts in digital learning. Hence, practitioners can refer to the results of our study to better adapt their game concepts to the context of learning. In addition, we provide an overview of topics that are relevant to consider when designing game concepts, thus enabling practitioners to better understand how game concepts have developed and will develop. This development is important for practitioners to better understand what they need to focus on in the future, such as using AI, which can make game concepts more intelligent but will require developing individualized game concepts that are better adapted to the needs of learners.

6. Limitations, future research, and conclusion

Our study has some limitations that may suggest areas for future research to complement what we present in our research agenda. First, although we overcame the limitations of the work of Parreno et al. (2016), we do not encourage other researchers to consider studies from other disciplines, such as management or marketing. Second, we only scratched the surface and provided an overview of more than 10,000 studies. Future research should concentrate on exploring the studies in more detail, covering aspects such as research designs and implications for research. Third, we provided a limited number of clusters. We encourage other researchers to further consider other kinds of clusters to gain a more detailed understanding of how specific groups of keywords have developed over time.

In this study, we present an overview of the state of the art of designing game concepts in digital learning. We present the most important sources and authors that have contributed significantly to theory and practice by establishing game concepts in digital learning. With our keyword analysis and the clustering of keywords, we identified the most important streams of research and their evolution and presented a research agenda. This enables us to identify directions for future research to contribute further to both theory and practice. Finally, this article is limited to metadata and citation counts that relied on WoS. Therefore, the citation counts and inclusivity are expected to be lower than in other databases (e.g., SCOPUS or Google Scholar) (Harzing & Alakangas, 2016; Kulkarni, Aziz, Shams, & Busse, 2009). However, we made this decision based on the advantage that WoS offers in terms of a well-maintained database, verified sources of articles, and rigorous quality control (Birkle, Pendlebury, Schnell, & Adams, 2020; Li, Rollins, & Yan, 2018). Search options such as Google Scholar have been heavily criticized for lack of quality (Halevi, Moed, & Bar-Ilan, 2017; Memon, 2018), inclusion of predatory journals (Ross-White, Godfrey, Sears, & Wilson, 2019; Severin & Low, 2019), non-scientific reports (Aguillo, 2012), and manipulation by bots and humans to inflate citations and H-index (Delgado López-Cózar, Robinson-García, & Torres-Salinas, 2014). A recent review of 91 studies comparing Google Scholar with other databases synthesized the evidence that Google Scholar lacks a transparent indexing policy, is inflated with duplications, has manipulated documents and, more importantly, lacks quality. Authors are cautioned against the use of Google Scholar for scholarly benchmarking or citation counts (Halevi et al., 2017). Mixing two databases for bibliometrics is not warranted, as it produces a faulty comparison. Since SCOPUS and WoS implement a different citation count strategy, an article in WoS may be assigned more citations that the same article in SCOPUS. Therefore, articles in either database alone will be at a disadvantage (Harzing & Alakangas, 2016; Kulkarni et al., 2009), and furthermore, this will result in erroneous H-indexes and unfair comparisons of articles and authors. However, it is up to future researchers to enlarge their search and include other databases.

Credit author statement

All authors were responsible for the conceptualization of the paper. The data and results were produced by Mohammed Saqr. Sofia Schöbel was responsible for the original draft and the supervision. Andreas Janson as well as Mohammed Saqr and Sofia Schöbel were responsible for writing, reviewing, and editing.

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Appendix A. Related Work

The following table summarizes key publications in relation to our studies goal. We identified meta analyses, as well as existing bibliometric studies and key literature reviews.

Reference	Kind of Study	Goal of Study	Strengthens &Limitations (compared to our study goal)	Future Research
de Freitas (2018)	Literature Review	Problematize the current scope of education studies and to reposition game science more critically within this educational context and perspective.	(+) Nice overview about development of games in education. Demonstration of contributions to other disciplines. (−) Limited view on studies because of method of literature review. Only a short discussion of different game concepts.	- Summarize contributions along different disciplines. - Analyze feedback system behind games in education. - Balance between game playability and fun and solid learning design.
Peterson (2010)		Analysis of the psycholinguistic and sociocultural constructs proposed as a basis for the use of games and simulations in computer assisted language learning	(+) Sociocultural and psycholinguistic view on games and their role in learning languages; demonstration of examples of how to work with games and simulations (−) It is a limited view on the state-of-the-art; what is claimed to be a meta-analysis is not per se a meta-analysis (when we think about it as comparing a large number of studies and the effect sizes of variables	- Enhanced understanding of the complex processes involved in language learning. - Investigate how simulation-based language learning may be facilitated in the dynamic learning environments.
Gao et al. (2020)		Understand the potential of mobile game-based learning in STEM education by identifying the studies context, research foci, research methodologies, features, research instruments and measurements	(+) Focus on mobile learning that provide useful insights about how to work with and consider mobile devices in STEM (−) With 30 studies considered it is only a limited view on the state-of-the-art of research and its future directions	- How does the inclusion or exclusion of specific game or mobile features affect the outcome of learning? - Is a particular combination of game and mobile features more effective to help learners to achieve their goals? - In what situation are intrinsically integrated games better than extrinsically integrated games? - How can mobile games be designed to meet the needs of students with different characteristics?
Girard, Ecalle, and Magnan (2013)		Review the results of experimental studies designed to examine the effectiveness of video games and serious games on players' learning and engagement	(+) Good overview about role of serious games in education and clarification on terms used (−) Only four years (2008–2011) are considered; selection of first 30 studies; only limited view on learning effects of games	- Working with control groups to analyze effectiveness of serious games. - Analyze effects of serious games in more detail regarding e.g. acquired knowledge. - Consider various types of serious games.
Wouters et al. (2013)	Meta-analysis	Investigation of effectiveness of serious games in learning and if they are more motivating than conventional instruction methods.	(+) Detailed overview on variables that support motivation and outcomes when working with serious games in learning (−) Focus on only serious games and on specific outcomes; because we have a meta-analysis it is only a limited number of studies considered (compared to a bibliometric study	- More value-added research on specific game features and their effectiveness (e.g. competitive elements). - Analyze cognitive consequences. - Examine definition of motivation.
Vogel et al. (2006)		Analysis of computer games and simulations that are used for learning compared to traditional approaches	(+) Large sample size in meta-analysis and comparison of effectiveness between concepts (−) Focus on specific variables and limited discussion of results	- Enlarge search (because many articles could not be used). - Working with control groups to analyze effectiveness. - Compare games and simulation with traditional methods of teaching.
Clark, Tanner-Smith, and Killingsworth (2016)		Systematic review on digital games and learning for K–16 students. Comparisons of game versus nongame conditions (i.e., media comparisons) and comparisons of augmented games versus standard game designs (i.e., value-added comparisons).	(+) Consideration of a large stream of literature; very detailed analysis and also analysis of moderators; supportive contributions for future research (−) Focus on games and serious games; study covers literature from 2000 to 2012	- Deeper assessments of student learning should be investigated in future research. - Explore whether or not the simple gamification studies (e.g., games that simply add contingent points and badges to learning activities) more frequently focus on lower order learning outcomes as compared to studies with more sophisticated game mechanics. - Analyze effectiveness of game characteristics.
Wu et al. (2012)		The study conducts a meta-analysis to investigate both the development of the use of learning theory as a foundation in game-based learning, or lack thereof, and the nature of links between the use of learning theory and game-based learning.	(+) Very detailed and supportive overview about theories that are important to learning and education (with a resulting strong contribution); good presentation of game-based learning to theories of learning	- Combine different academic fields (i.e. education, psychology, computer science and engineering or management) and even include specialists from industry to collaboratively develop a game-based learning system

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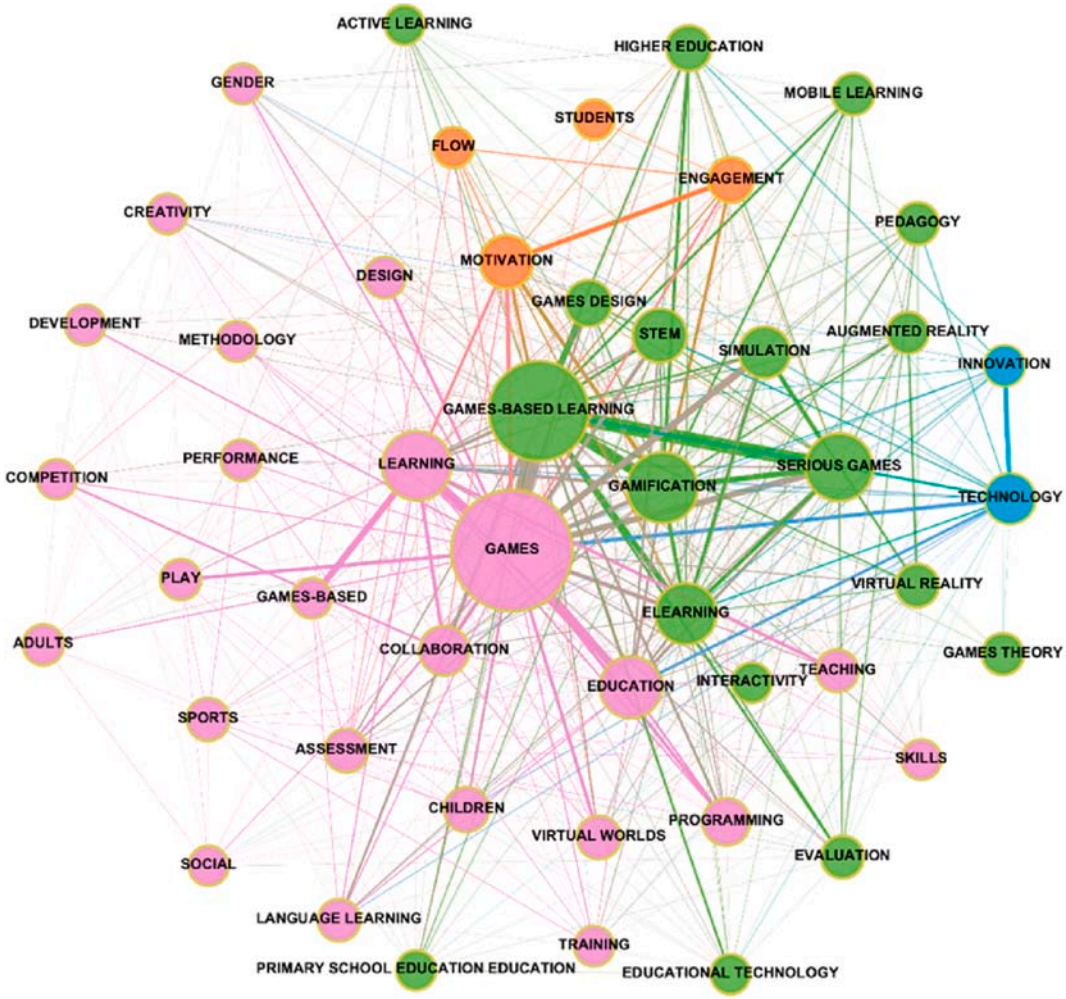
(*continued*)

Reference	Kind of Study	Goal of Study	Strengthens &Limitations (compared to our study goal)	Future Research
			(−) Limited presentation of meta analytic outcomes; very short cut results discussion	or platform to increase the proportion and use of learning-theory foundations in game-based learning - Apply different types of game elements to principles of behaviorism and cognitivism (or combinations)
Lamb et al. *(2018)*		Characterize and compare outcomes related to serious educational games, serious games, and educational simulations as they are presented in the educational literature.	(+) Good overview about the effectiveness of serious games in education; well done meta-analysis and included moderator analysis (−) Focus on only a limited number of studies; focus on serious games that are only one part of game concepts	- Need to include more moderators. - Differentiation between the more specific term of educational simulation. - Need for long-term analysis.
Chian-Wen (2014)		Analysis of effectiveness of digital games and how they improve language learning and identification of moderating variables in digital game-based learning	(+) Overview about existing meta-analyses; well done meta-analysis and analysis of moderating variables; demonstration of relationship between game-based learning and learning languages (−) Limited to language learning so only a focused view on the state-of-the-art; limited number of databases considered	- Consider other databases for search. - Consider more variables to understand effectiveness of games in digital learning. - Explore affective outcomes not only cognitive ones - Analysis of long-term effects.
Karakus et al. *(2019)*	Bibliometric Study	Analysis of how AR has developed in education considering studies from 1999 to 2018	(+) Nice overview about the establishment of AR along the years and how they have been developed (−) Keyword analysis is rather short, and the role of games is not discussed in detail (at least to what we want to achieve with our study)	- Analyze learner characteristics and experience in future research.
Marti-Parreno et al. (2016)		Provide useful up-to-date information to picture the state of the art about current research and evolution of gamification in education	(+) Helpful recommendations regarding effectiveness, acceptance, engagement and social interaction (−) Only focus on journal articles; limited time period (only from 2010 to 2014); comparison of only 139 articles	- Enlarge search to more than five years and include proceedings. - More research about clarifying game-based learning, serious games and gamification. - Research about how to integrate games and game elements in traditional learning frameworks.
Trinidad et al. *(2021)*		Conduct a bibliometric study to describe how gamification as scientific perspective is structured and how it has evolved over time.	(+) Very detailed overview about gamification in general with all perspectives (authors, keywords, countries) (−) Limited time period (2011–2019) research involving gamification has started around 2000; learning is highlighted as important but not focused analysis is done	- More knowledge about effective game designs (and new elements). - Personalized and adaptive data-driven gamification. - Empirical research that helps to offer verifiable evidence of positive and negative effects of gamification. - Ethical use of gamification.

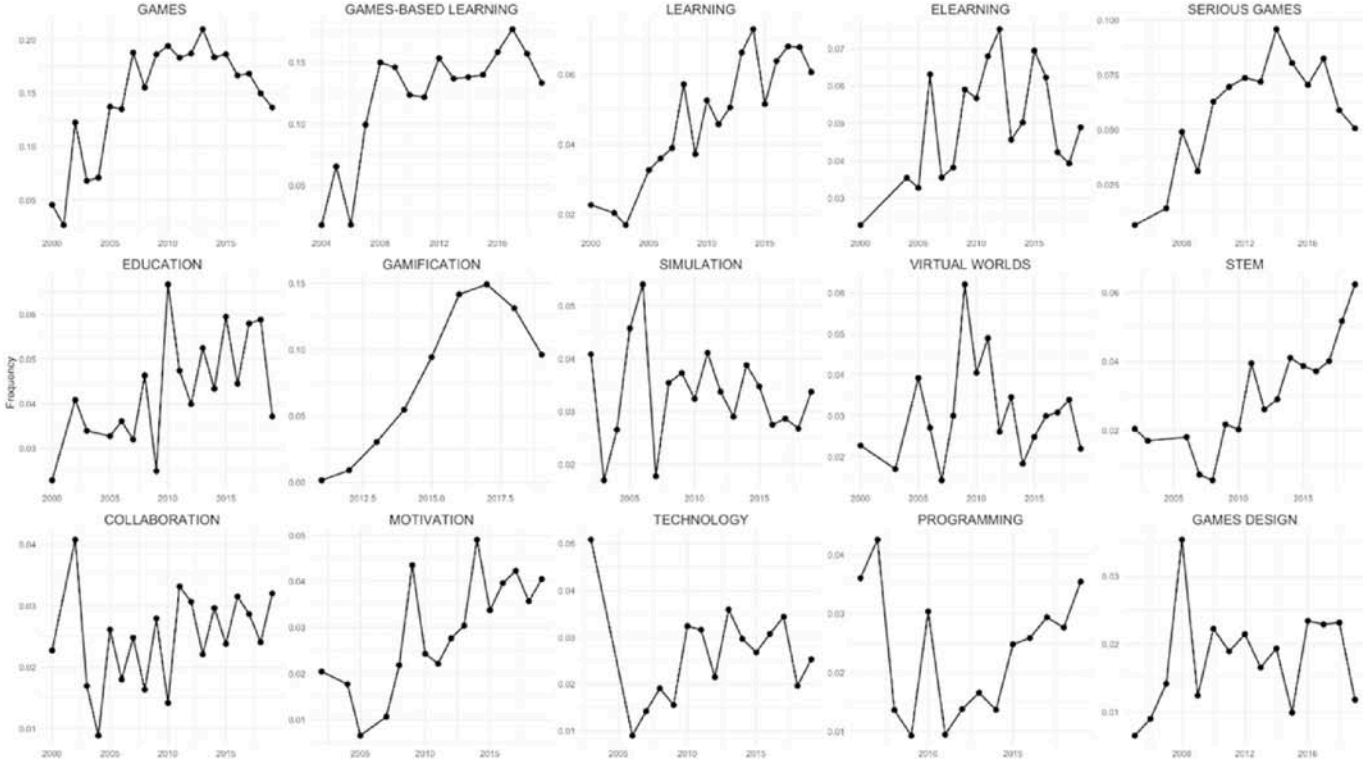
Appendix B. Keyword Network

The keywords that were most often used in combination with each other were games, game-based learning, gamification, and serious games. They were also the keywords that were most often used among all keywords we identified. Motivation seemed to be relevant when using with gamification, other than engagement, which was more often referred to in combination with motivation. Simulations seemed to be of relevance for games and serious games but not as important for gamification. More interesting was that game design was often not connected to gamification or serious games but rather to game-based learning. Furthermore, performance was part of the keywords, but it was not intensively connected to the other keywords and did not have a strong relationship to other keywords like the one we saw between games and game-based learning.



Appendix C. Detailed Overview Keyword Development

The following figure displays a detailed overview about the most relevant keywords and their development over time.


GAMES
GAMES-BASED LEARNING
LEARNING
ELEARNING
SERIOUS GAMES
EDUCATION
GAMIFICATION
SIMULATION
VIRTUAL WORLDS
STEM
COLLABORATION
MOTIVATION
TECHNOLOGY
PROGRAMMING
GAMES DESIGN
Frequency

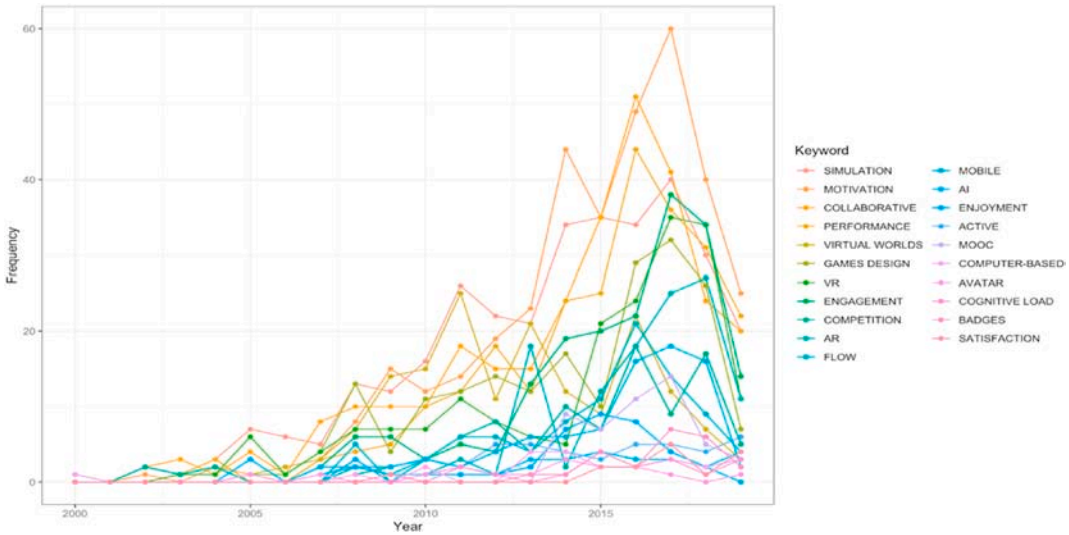
Appendix D. Description of Keyword Clusters

We identified and derived clusters from literature to consolidate the large number of identified keywords. E.g., we considered different kind of outcomes describing different effects and results when working with game concepts in digital learning.

Cluster	Description
Outcomes	The effectiveness of working with games has intensively been discussed in literature. Some studies claim that we need to get a better understanding about how games and its elements affect outcomes such as engagement (Hamari et al., 2016). This cluster considers all kind of outcomes that can result from working with games and its elements such as engagement and motivation that are central outcomes to analyze the effectiveness of games (Muntean, 2011; Vos, van der Meijden, & Denessen, 2011). As our study focusses on education and learning, we considered performances as another outcome.
Environment and Devices	Learning can happen in different context and with different kind of devices (e.g., mobile or computer-based learning (Bartel & Hagel, 2014; Fitz-Walter, Tjondronegoro, & Wyeth, 2012)). The device worked with and environment worked in, determine the design of a game concept. This cluster considers different devices and environments to explore trends towards environments and devices.
Dynamics	Dynamics describe describes the run-time behavior of game elements used in a concept, acting on users inputs and each other's outputs over time (Hunicke et al., 2004).They give an overview of how a game concept is grounded e.g., as competitive concept aiming to increase competition between users.
Elements	Elements are central components of a game (Seaborn & Fels, 2015). This cluster considers keywords that directly refer to game elements such as badges or avatars.
Technology Trends	These cluster considers both AR and VR as technology trends that have become more and more relevant during the last years and that change a learner's gaming experience (Zyda, 2005).
Others	In a last cluster we consider two keywords that are relevant to better understand how games in digital learning have developed and will develop. First, game design is important to make concepts of working with games more meaningful (Hong, Hwang, Tai, & Kuo, 2016; Salen & Zimmerman, 2004). Lastly, working with AI allows us to develop new and innovative game concepts in the future to better adapt and individualize such concepts to the needs of users (Schöbel et al., 2020).

Appendix E. Consolidated Growth per Year

The following Figure summarizes the consolidated yearly growth of our keywords.



References

Abramo, G., D'Angelo, C. A., & Di Costa, F. (2011). National research assessment exercises: A comparison of peer review and bibliometrics rankings. *Scientometrics, 89*(3), 929–941.

Aguillo, I. F. (2012). Is Google scholar useful for bibliometrics? A webometric analysis. *Scientometrics, 91*(2), 343–351.

Ahmad, A., Zeshan, F., Khan, M. S., Marriam, R., Ali, A., & Samreen, A. (2020). The impact of gamification on learning outcomes of computer science majors. *ACM Transactions on Computing Education (TOCE), 20*(2), 1–25.

Aria, M., & Cuccurullo, C. (2017). bibliometrix: An R-tool for comprehensive science mapping analysis. *Journal of Informetrics, 11*(4), 959–975.
Ayres, P. (2020). *Something old, something new from cognitive load theory*. Elsevier.
Ayres, P., & Paas, F. (2007). Making instructional animations more effective: A cognitive load approach. *Applied Cognitive Psychology: The Official Journal of the Society for Applied Research in Memory and Cognition, 21*(6), 695–700.
Bai, S., Hew, K. F., & Huang, B. (2020). Is gamification "bullshit"? Evidence from a meta-analysis and synthesis of qualitative data in educational contexts. *Educational Research Review*.
Barab, S., Thomas, M., Dodge, T., Carteaux, R., & Tuzun, H. (2005). Making learning fun: Quest Atlantis, a game without guns. *Educational Technology Research & Development, 53*(1), 86–107.
Bartel, A., & Hagel, G. (2014). Engaging students with a mobile game-based learning system in university education. *Global Engineering Education Conference*, 957–960.
Bedwell, W. L., Pavlas, D., Heyne, K., Lazzara, E. H., & Salas, E. (2012). Toward a taxonomy linking game attributes to learning: An empirical study. *Simulation & Gaming, 43*(6), 729–760. https://doi.org/10.1177/1046878112439444
Birkle, C., Pendlebury, D. A., Schnell, J., & Adams, J. (2020). Web of Science as a data source for research on scientific and scholarly activity. *Quantitative Science Studies, 1*(1), 363–376.
Boyle, E. A., MacArthur, E. W., Connolly, T. M., Hainey, T., Manea, M., Kärki, A., et al. (2014). A narrative literature review of games, animations and simulations to teach research methods and statistics. *Computers & Education, 74*, 1–14.
Bunchball, I. (2010). *Gamification 101: An introduction to the use of game dynamics to influence behavior* (Vols. 1–14). Bunchball Inc. (White Paper).
Burgers, C., Eden, A., van Engelenburg, M. D., & Buningh, S. (2015). How feedback boosts motivation in play in a brain-training game. *Computers in Human Behavior, 48*, 94–103.
Burguillo, J. C. (2010). Using game theory and competition-based learning to stimulate student motivation and performance. *Computers & Education, 55*(2), 566–575.
Chen, Ching-Huei, Shih, Chun-Chao, & Law, Victor (2020). The effects of competition in digital game-based learning (DGBL): a meta-analysis. *Educational technology research and development, 68*(4), 1855–1873.
Chen, Z.-H., Liao, C. C. Y., Cheng, H. N. H., Yeh, C. Y. C., & Chan, T.-W. (2012). Influence of game quests on pupils' enjoyment and goal-pursuing in math learning. *Journal of Educational Technology & Society, 15*(2), 317–327.
Chian-Wen, K. A. O. (2014). The effects of digital game-based learning task in English as a foreign language contexts: A meta-analysis. *Education Journal, 42*(2), 113–141.
Christy, K. R., & Fox, J. (2014). Leaderboards in a virtual classroom: A test of stereotype threat and social comparison explanations for women's math performance. *Computers & Education, 78*, 66–77.
Clark, D. B., Tanner-Smith, E. E., & Killingsworth, S. S. (2016). Digital games, design, and learning: A systematic review and meta-analysis. *Review of Educational Research, 86*(1), 79–122.
Connolly, T. M., Stansfield, M., & Hainey, T. (2011). An alternate reality game for language learning: ARGuing for multilingual motivation. *Computers & Education, 57*(1), 1389–1415.
Cruz, C., Hanus, M. D., & Fox, J. (2017). The need to achieve: Players' perceptions and uses of extrinsic meta-game reward systems for video game consoles. *Computers in Human Behavior, 71*, 516–524.
Davis, K., & Singh, S. (2015). Digital badges in afterschool learning: Documenting the perspectives and experiences of students and educators. *Computers & Education, 88*, 72–83.
De-Marcos, L., Garcia-Lopez, E., & Garcia-Cabot, A. (2016). On the effectiveness of game-like and social approaches in learning: Comparing educational gaming, gamification & social networking. *Computers & Education, 95*, 99–113.
Deci, E. L., Ryan, R. M., Gagne, M., Leone, D. R., Usunov, J., & Kornazheva, B. P. (2001). Need satisfaction, motivation, and well-being in the work organizations of a former eastern bloc country: A cross-cultural study of self-determination. *Personality and Social Psychology Bulletin, 27*(8), 930–942.
Delgado López-Cózar, E., Robinson-García, N., & Torres-Salinas, D. (2014). The G oogle scholar experiment: How to index false papers and manipulate bibliometric indicators. *Journal of the Association for Information Science and Technology, 65*(3), 446–454.
Deterding, S., Dixon, D., Khaled, R., & Nacke, L. (2011a). From game design elements to gamefulness: Defining gamification. *Mind, 9–15*.
Deterding, S., Sicart, M., Nacke, L., O'Hara, K., & Dixon, D. (2011b). Gamification: Using game design elements in non-gaming contexts. *Human Factors in Computing Systems*, 2425–2428.
Dissanayake, I., Mehta, N., Palvia, P., Taras, V., & Amoako-Gyampah, K. (2019). *Competition matters! Self-efficacy, effort, and performance in crowdsourcing teams* (pp. 103–158). Information & Management.
Domínguez, A., Saenz-de-Navarrete, J., de-Marcos, L., Fernández-Sanz, L., Páges, C., & Martínez-Herráiz, J.-J. (2013). Gamifying learning experiences: Practical implications and outcomes. *Computers & Education, 63*, 380–392.
Dunleavy, M., Dede, C., & Mitchell, R. (2009). Affordances and limitations of immersive participatory augmented reality simulations for teaching and learning. *Journal of Science Education and Technology, 18*(1), 7–22.
Ebner, M., & Holzinger, A. (2007). Successful implementation of user-centered game based learning in higher education: An example from civil engineering. *Computers & Education, 49*(3), 873–890.
Ernst, S-J, Janson, A, Söllner, M, & Leimeister, JM (2016). It's about Understanding Each Other's Culture - Improving the Outcomes of Mobile Learning by Avoiding Culture Conflicts. *ICIS 2016 Proceedings*.
Fitz-Walter, Z., Tjondronegoro, D., & Wyeth, P. (2012). A gamified mobile application for engaging new students at university orientation. *Proceedings of the 24th Australian Computer-Human Interaction Conference*, 138–141.
Freitas, S. de (2018). Are games effective learning tools? A review of educational games. *Journal of Educational Technology & Society, 21*(2), 74–84.
Freitas, S. de, & Oliver, M. (2006). How can exploratory learning with games and simulations within the curriculum be most effectively evaluated? *Computers & Education, 46*(3), 249–264.
Gao, F., Li, L., & Sun, Y. (2020). A systematic review of mobile game-based learning in STEM education. *Educational Technology Research & Development, 68*(4), 1791–1827.
Girard, C., Ecalle, J., & Magnan, A. (2013). Serious games as new educational tools: How effective are they? A meta-analysis of recent studies. *Journal of Computer Assisted Learning, 29*(3), 207–219.
Gupta, S., & Bostrom, R. (2013). Research note—an investigation of the appropriation of technology-mediated training methods incorporating enactive and collaborative learning. *Information Systems Research, 24*(2), 454–469.
Hainey, T., Connolly, T. M., Stansfield, M., & Boyle, E. A. (2011a). Evaluation of a game to teach requirements collection and analysis in software engineering at tertiary education level. *Computers & Education, 56*(1), 21–35.
Hainey, T., Hakulinen, L., Connolly, T., Stansfield, M., & Boyle, E. (2011b). The differences in motivations of online game players and offline game players: A combined analysis of three studies at higher education level. *Computers & Education, 57*(4), 2197–2211.
Hakulinen, L., & Auvinen, T. (2014). The effect of gamification on students with different achievement goal orientations. *International Conference on Teaching and Learning in Computing and Engineering (IEEE)*, 9–16.
Halevi, G., Moed, H., & Bar-Ilan, J. (2017). Suitability of Google Scholar as a source of scientific information and as a source of data for scientific evaluation—review of the literature. *Journal of Informetrics, 11*(3), 823–834.
Hallifax, S., Serna, A., Marty, J.-C., Lavoué, G., & Lavoué, E. (2019). Factors to consider for tailored gamification. *Proceedings of the Annual Symposium on Computer-Human Interaction in Play*, 559–572.
Hamari, J., & Koivisto, J. (2015). Working out for likes": An empirical study on social influence in exercise gamification. *Computers in Human Behavior, 50*, 333–347.
Hamari, J., Koivisto, J., & Sarsa, H. (2014). *Does gamification work? A literature review of empirical studies on gamification* (pp. 3025–3034). Hawaii International Conference on System Science (HICSS).

Hamari, J., Shernoff, D. J., Rowe, E., Coller, B., Asbell-Clarke, J., & Edwards, T. (2016). Challenging games help students learn: An empirical study on engagement, flow and immersion in game-based learning. *Computers in Human Behavior, 54*, 170–179.
Hanus, M. D., & Fox, J. (2015). Assessing the effects of gamification in the classroom: A longitudinal study on intrinsic motivation, social comparison, satisfaction, effort and, academic performance. *Computers & Education, 80*, 152–161.
Harzing, A.-W., & Alakangas, S. (2016). Google scholar, scopus and the Web of science: A longitudinal and cross-disciplinary comparison. *Scientometrics, 106*(2), 787–804.
Hirsch, J. E. (2005). An index to quantify an individual's scientific research output. *Proceedings of the National Academy of Sciences, 102*(46), 16569–16572.
Hong, J.-C., Hwang, M.-Y., Tai, K.-H., & Kuo, Y.-C. (2016). Crystallized intelligence affects hedonic and epistemic values to continue playing a game with saliency-based design. *Computers & Education, 95*, 75–84.
Hong, J.-C., & Liu, M.-C. (2003). A study on thinking strategy between experts and novices of computer games. *Computers in Human Behavior, 19*(2), 245–258.
Huizinga, J. (1949). *Homo ludens*. Boston: The Beacon Press.
Hunicke, R., LeBlanc, M., & Zubek, R. (2004). *Methoden, Daten und Analyse: A formal approach to game design and game research, 4*(1), 1–5.
Ibánez, M.-B., Di-Serio, Á., & Delgado-Kloos, C. (2014). Gamification for engaging computer science students in learning activities: A case study. *IEEE Transactions on Learning Technologies, 7*(3), 291–301.
Janson, A, Söllner, M, & Leimeister, JM (2017). Individual Appropriation of Learning Management Systems — Antecedents and Consequences. *AIS Transactions on Human-Computer Interaction, 9*(3), 173–201.
Janson, A, Söllner, M, & Leimeister, JM (2020). Ladders for Learning: Is Scaffolding the Key to Teaching Problem-Solving in Technology-Mediated Learning Contexts? *Academy of Management Learning & Education, 19*(4), 439–468. https://doi.org/10.5465/amle.2018.0078
Karakus, M., Ersozlu, A., & Clark, A. C. (2019). Augmented reality research in education: A bibliometric study. *Eurasia Journal of Mathematics, Science and Technology Education, 15*(10), Article em1755.
Katsaliaki, K. (2013). Serious games for sustainable development. *Journal of Management Education, 37*(6), 889–894.
Kulkarni, A. V., Aziz, B., Shams, I., & Busse, J. W. (2009). Comparisons of citations in Web of Science, Scopus, and Google Scholar for articles published in general medical journals. *Jama, 302*(10), 1092–1096.
Kuo, M.-S., & Chuang, T.-Y. (2016). How gamification motivates visits and engagement for online academic dissemination–An empirical study. *Computers in Human Behavior, 55*, 16–27.
Kurniawan, H. C., Sitohang, B., & Rukmono, S. A. Gamification of mobile-based Japanese language shadowing. International Conference of Artificial Intelligence and Information Technology (ICAIIT), 215–219.
Lamb, R. L., Annetta, L., Firestone, J., & Etopio, E. (2018). A meta-analysis with examination of moderators of student cognition, affect, and learning outcomes while using serious educational games, serious games, and simulations. *Computers in Human Behavior, 80*, 158–167.
Landers, R. N. (2015). Developing a theory of gamified learning: Linking serious games and gamification of learning. *Simulation & Gaming, 45*(6), 752–768. https://doi.org/10.1177/1046878114563660
Liao, H., Mariani, M. S., Medo, M., Zhang, Y.-C., & Zhou, M.-Y. (2017). Ranking in evolving complex networks. *Physics Reports, 689*, 1–54.
Li, N., & Kirkup, G. (2007). Gender and cultural differences in internet use: A study of China and the UK. *Computers & Education, 48*(2), 301–317.
Li, K., Rollins, J., & Yan, E. (2018). Web of science use in published research and review papers 1997–2017: A selective, dynamic, cross-domain, content-based analysis. *Scientometrics, 115*(1), 1–20.
Liu, D., Li, X., & Santhanam, R. (2013). Digital games and beyond: What happens when players compete. *MIS Quarterly, 327*(1), 111–124.
Liu, Zhichun, Moon, Jewoong, Kim, Byungjoo, & Dai, Chih-Pu (2020). Integrating adaptivity in educational games: a combined bibliometric analysis and meta-analysis review. *Educational technology research and development*, 1–29.
Lowry, P. B., Petter, S., & Leimeister, J. M. (2020). Desperately seeking the artefacts and the foundations of native theory in gamification research: Why information systems researchers can play a legitimate role in this discourse and how they can better contribute. *European Journal of Information Systems, 29*(6), 609–620.
Martí-Parreño, J., Méndez-Ibáñez, E., & Alonso-Arroyo, A. (2016). The use of gamification in education: A bibliometric and text mining analysis. *Journal of Computer Assisted Learning, 32*(6), 663–676.
Mekler, E. D., Brühlmann, F., Tuch, A. N., & Opwis, K. (2017). Towards understanding the effects of individual gamification elements on intrinsic motivation and performance. *Computers in Human Behavior, 71*, 525–534.
Memon, A. R. (2018). Predatory journals spamming for publications: What should researchers do? *Science and Engineering Ethics, 24*(5), 1617–1639.
Meo, P. de, Ferrara, E., Fiumara, G., & Provetti, A. (2011). Generalized louvain method for community detection in large networks. *International Conference on Intelligent Systems Design and Applications*, 88–93.
Muntean, C. I. (2011). Raising engagement in e-learning through gamification. *International Conference on Virtual Learning ICVL*, 323–329.
Peterson, M. (2010). Computerized games and simulations in computer-assisted language learning: A meta-analysis of research. *Simulation & Gaming, 41*(1), 72–93.
Putz, L.-M., Hofbauer, F., & Treiblmaier, H. (2020). Can gamification help to improve education? Findings from a longitudinal study. *Computers in Human Behavior*, 106–392.
Ross-White, A., Godfrey, C. M., Sears, K. A., & Wilson, R. (2019). Predatory publications in evidence syntheses. *Journal of the Medical Library Association: JMLA, 107*(1), 57.
Rowe, J. P., Shores, L. R., Mott, B. W., & Lester, J. C. (2011). Integrating learning, problem solving, and engagement in narrative-centered learning environments. *International Journal of Artificial Intelligence in Education, 21*(1–2), 115–133.
Sailer, M., Hense, J. U., Mayr, S. K., & Mandl, H. (2017). How gamification motivates: An experimental study of the effects of specific game design elements on psychological need satisfaction. *Computers in Human Behavior, 69*, 371–380.
Sailer, M., & Homner, L. (2019). The gamification of learning: A meta-analysis. *Educational Psychology Review*, 1–36.
Salen, K., & Zimmerman, E. (2004). *Rules of play: Game design fundamentals*. Massachusetts: MIT Press.
Santhanam, R., Liu, D., & Milton-Shen, W.-C. (2016). Research note-gamification of technology-mediated training: Not all competitions are the same. *Information Systems Research, 27*(2), 453–465.
Sauvé, L., Renaud, L., & Kaufman, D. (2010). Games, simulations, and simulation games for learning: Definitions and distinctions. *Educational gameplay and simulation environments: Case studies and lessons learned*. IGI Global.
Scheiner, C. (2015). The motivational fabric of gamified idea competition: The evaluation of game mechanics from a longitudinal perspective. *Creativity and Innovation Management, 24*(2), 341–352.
Schöbel, S., Janson, A., Jahn, K., Kordyaka, B., Turetken, O., Djafarova, N., … Adam, M. (2020). *A research agenda for the why, what, and how of gamification designs results on an ECIS 2019 panel*. Communications of the Association for Information Systems.
Schöbel, S, Janson, A, & Mishra, A (2019). A Configurational View on Avatar Design – The Role of Emotional Attachment, Satisfaction, and Cognitive Load in Digital Learning. *ICIS 2019 Proceedings*.
Seaborn, K., & Fels, D. I. (2015). Gamification in theory and action: A survey. *International Journal of Human-Computer Studies, 74*, 14–31.
Severin, A., & Low, N. (2019). *Readers beware! Predatory journals are infiltrating citation databases*. Springer.
Silva, R., Rodrigues, R., & Leal, C. (2020). Gamification in management education-A literature mapping. *Education and Information Technologies, 25*(3), 1803–1835.
Simoes, J., Díaz Redondo, R., & Fernández Vilas, A. (2013). A social gamification framework for K-6 learning platform. *Computers in Human Behavior, 29*(2), 345–353.
Suh, A., Cheung, C. M. K., Ahuja, M., & Wagner, C. (2017). Gamification in the workplace: The central role of the aesthetic experience. *Journal of Management Information Systems, 34*(1), 268–305.
Sung, H.-Y., & Hwang, G.-J. (2013). A collaborative game-based learning approach to improving students' learning performance in science courses. *Computers & Education, 63*, 43–51.
Super, J., Keller, R. H., Betts, T. K., & Roach Humphreys, J. (2019). Simulation games: Learning goal orientations and norms for knowledge sharing. *Academy of Management Proceedings*, (1).

Sweller, J. (1994). Cognitive load theory, learning difficulty, and instructional design. *Learning and Instruction, 4*(4), 295–312. https://doi.org/10.1016/0959-4752(94)90003-5

Trinidad, M., Ruiz, M., & Calderón, A. (2021). A bibliometric analysis of gamification research. *IEEE Access, 9*, 46505–46544.

Vogel, J. J., Vogel, D. S., Cannon-Bowers, J., Bowers, C. A., Muse, K., & Wright, M. (2006). Computer gaming and interactive simulations for learning: A meta-analysis. *Journal of Educational Computing Research, 34*(3), 229–243.

Vom Brocke, J., Simons, A., Riemer, K., Niehaves, B., Plattfaut, R., & Cleven, A. (2015). Standing on the shoulders of giants: Challenges and recommendations of literature search in information systems research. *Communications of the Association for Information Systems, 37*(9), 205–244.

Vos, N., van der Meijden, H., & Denessen, E. (2011). Effects of constructing versus playing an educational game on student motivation and deep learning strategy use. *Computers & Education, 56*(1), 127–137. https://doi.org/10.1016/j.compedu.2010.08.013

Webster, J., & Watson, R. T. (2002). Analyzing the past to prepare for the future: Writing a literature review. *MIS Quarterly, 26*(2), 13–23.

Werbach, K., & Hunter, D. (2012). *For the win: How game thinking can revolutionize your business*. Wharton Digital Press.

Wong, J., Khalil, M., Baars, M., Koning, B. B. de, & Paas, F. (2019). Exploring sequences of learner activities in relation to self-regulated learning in a massive open online course. *Computers & Education, 140*, 103595.

Wouters, P., van Nimwegen, C., van Oostendorp, H., & Van Der Spek, E. D. (2013a). A meta-analysis of the cognitive and motivational effects of serious games. *Journal of Educational Psychology, 105*(2), 1–17.

Wu, W.-H., Hsiao, H.-C., Wu, P.-L., Lin, C.-H., & Huang, S.-H. (2012). Investigating the learning-theory foundations of game-based learning: A meta-analysis. *Journal of Computer Assisted Learning, 28*(3), 265–279.

Yien, J.-M., Hung, C.-M., Hwang, G.-J., & Lin, Y.-C. (2011). A game-based learning approach to improving students' learning achievements in a Nutrition course. *Turkish Online Journal of Educational Technology-TOJET, 10*(2), 1–10.

Yu, F.-Y., Chang, L.-J., Liu, Y.-H., & Chan, T.-W. (2002). Learning preferences towards computerised competitive modes. *Journal of Computer Assisted Learning, 18*(3), 341–350.

Zainuddin, Z., Chu, S. K. W., Shujahat, M., & Perera, C. J. (2020). The impact of gamification on learning and instruction: A systematic review of empirical evidence. *Educational Research Review*.

Zhang, F., & Kaufman, D. (2016). Physical and cognitive impacts of digital games on older adults: A meta-analytic review. *Journal of Applied Gerontology, 35*(11), 1189–1210.

Zyda, M. (2005). From visual simulation to virtual reality to games. *Computer Society, 38*(9), 25–32.