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Revealing the theoretical basis of gamification: A systematic review and analysis of theory in research on gamification, serious games and game-based learning☆

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ABSTRACT

Despite increasing scientific interest in explaining how gamification supports positive affect and motivation, behavior change and learning, there is still a lack of an overview of the current theoretical understanding of the psychological mechanisms of gamification. Previous research has adopted several different angles and remains fragmented. Taking both an observational and explanatory perspective, we examined the theoretical foundations used in research on gamification, serious games and game-based learning through a systematic literature review and then discussed the commonalities of their core assumptions. The overview shows that scientists have used a variety of 118 different theories. Most of them share explicitly formulated or conceptual connections. From their interrelations, we derived basic principles that help explain how gamification works: Gamification can illustrate goals and their relevance, nudge users through guided paths, give users immediate feedback, reinforce good performance and simplify content to manageable tasks. Gamification mechanics can allow users to pursue individual goals and choose between different progress paths, while the system can adapt complexity to the user's abilities. Social gamification elements may enable social comparison and connect users to support each other and work towards a common goal.

1. Introduction

Games are a crucial aspect of human culture and society and promote motivation and engagement (Bozkurt & Durak, 2018). This is why the mechanics of gaming are increasingly transferred to generally game-free contexts, such as primary and secondary school education (e.g. Ioannou, 2019; Rachels & Rockinson-Szapkiw, 2018; Zainuddin, 2018), adult and higher education (e.g. Barata et al., 2017; Huang et al., 2019; Huang & Hew, 2018) healthcare and fitness (e. g. Orji & Moffatt, 2018; Sardi et al., 2017), the workplace (e.g. Passalacqua et al., 2020; Perryer et al., 2016) or consumer behavior (e.g. Morganti et al., 2017; Tobon et al., 2020), to promote desired motivational, behavior and learning outcomes (Zainuddin et al., 2020).

Gamification, denoting the above-mentioned use of game elements in non-game contexts (Deterding et al., 2011), is linked to effects on affect and motivation (e.g. Albertazzi et al., 2019; Ding et al., 2017; Hamari et al., 2014; Koivisto & Hamari, 2019), on behavior, e.g., academic achievement and engagement (e.g. Barata et al., 2017; Huang et al., 2019; Koivisto & Hamari, 2019; Putz et al., 2020; Zainuddin, 2018) and on (cognitive) learning (e.g. Connolly et al., 2012; Vlachopoulos & Makri, 2017). However, results are sometimes ambiguous (Hamari et al., 2014; Sailer & Homner, 2020), for instance concerning the effect of gamification on intrinsic or extrinsic motivation (e.g. Biles et al., 2014; Hanus & Fox, 2015; Mekler et al., 2017) or enjoyment (Koivisto & Hamari, 2019). Gamification is thus not effective per se (Sailer et al., 2017). Rather, the design of effective gamified interventions, which also include serious games and game-based learning, requires theoretical knowledge of hitherto unexplored cognitive, emotional and motivational mechanisms through which gamification achieves its impact (Cheng et al., 2015; Koivisto & Hamari, 2019; Sailer & Homner, 2020) to successfully decide on appropriate structures, mechanics and principles (Dichev & Dicheva, 2017). Scientific studies increasingly investigate the use of different theoretical foundations such as motivation, behavior, or learning theories to explain the effect of certain gamification elements or design gamification (Nacke & Deterding, 2017). However, existing reviews on gamification, serious games

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and game-based learning, in which the scope is naturally determined by the application context and the focus of the review in terms of content, so far do not reflect the entire diverging theoretical landscape. Albeit only a synthesis of the fragmented considerations from different disciplines leads to the depiction of the current state of theory in research and the identification of theoretical commonalities and basic principles that help explain how gamification works.

The gap of a comprehensive overview and analysis of theoretical foundations in gamification research requires a systematic investigation of the theories used to explain, design and evaluate gamification to guide future theoretical and empirical research. Consequently, this meta-review – a review of reviews in contrast to the analysis of primary research studies (Gough et al., 2017) – is the first to explicitly focus on the theoretical basis of gamification and aims to *identify the theoretical foundations* used in primary studies mentioned in reviews on gamification, serious games and game-based learning both in general and in specific domains. In addition, it aims to *compare and interlink the identified theoretical foundations* to create an overview of the theoretical research landscape, *discuss the common principles of how gamification works* and open up avenues for further theory development. Thus, starting from an observational perspective, the theories presented and their popularity in gamification research are reviewed, followed by a shift to an explanatory perspective, through which the relationships and commonalities of the identified theoretical foundations are analyzed. This ultimately leads to the derivation of basic theoretical principles from the underlying foundations that help explain the effects of gamification and support successful gamification design.

2. Background and previous research

2.1. Game, gamification, serious games and game-based learning

A *game* refers to a structured play with rules, goals and challenges for the purpose of entertainment (Cheng et al., 2015). The term *gamification* first emerged in 2008 and gained increasing relevance since the 2010s (Deterding et al., 2011; Seaborn & Fels, 2015). In contrast to games, gamification is characterized by its serious purpose. Definitions of gamification vary and usually focus either on game elements and mechanics or the process of gaming and gameful experiences in serious contexts. Deterding et al. (2011, p. 11) define gamification as the "use of game elements in non-game contexts". Game elements are, for example, levels, points, badges, leader boards, avatars, quests, social graphs, or certificates (Zainuddin et al., 2020). Kapp et al., (2014, p. 54) highlight the usage of "game-based mechanics, aesthetics, and game-thinking to engage people, motivate action, promote learning, and solve problems". Zichermann and Cunningham (2011, p. xiv) denote gamification as "the process of game-thinking and game mechanics to engage and solve problems". Synthesizing these different perspectives, Seaborn and Fels (2015) state a possible standard definition, namely gamification as "the intentional use of game elements for a gameful experience of non-game tasks and contexts" (Seaborn & Fels, 2015, p. 17). Gamification mechanics, such as rewards and loyalty programs in marketing and grades in schools, were already used long before the emergence of the gamification research area at the beginning of the decade. More recently, the concept has been transferred and adapted to different contexts, such as education in general, the workplace and health, perhaps due to cheaper technology, tracking of personal data, the game studies movement and the general prevalence of video games as a medium (Seaborn & Fels, 2015).

Gamification is closely related to two other concepts: serious games and game-based learning. *Game-based learning* refers to the achievement of defined learning outcomes through game content and play and enhancing learning by involving problem-solving spaces and challenges that provide learners, who are also players, with a sense of achievement (Qian & Clark, 2016). Game-based learning intends to educate. It relies on a fully-fledged game, commonly named *serious game*. Beyond education, serious games (Abt, 1970) are games intended for a variety of serious purposes, for example in industry, training, or stimulation (Alsawaier, 2018; Connolly et al., 2012). Even though serious games and game-based learning differ from gamification because they are full-featured games (Deterding et al., 2011), while gamification as a broader concept only utilizes components of games and applies them to the real environment, all concepts share the idea of using positive gameful experiences for the sake of a serious purpose, for example, education or behavior change, rather than focusing on entertainment.

2.2. Effects and outcomes of gamification, serious games and game-based learning

When investigating the outcomes of gamification, serious games or game-based learning, scholars typically distinguish between behavioral outcomes, (cognitive) learning outcomes, and either affective outcomes (Carenys & Moya, 2016; Lamb et al., 2018), motivational outcomes (Sailer & Homner, 2020) or both (Connolly et al., 2012; Ekici, 2021). Motivational outcomes are sometimes also classified as a subcategory of affective outcomes (Dichev & Dicheva, 2017; Vlachopoulos & Makri, 2017), similar to the distinction in Bloom's taxonomy of educational objectives (Bloom, 1956).

Affective and motivational outcomes. One of the reasons why gamification, serious games and game-based learning have become so popular is that gaming is considered as motivating (Bai et al., 2020). Motivation explains the "why" of human behavior: it describes all internal processes giving behavior its energy and direction (Reeve, 1996). Motivation is a hypothetical construct that manifests in behavior and can lead to positive cognitive outcomes such as improved learning and achievement (e.g. Keller, 2008). In the educational context, high-quality motivation, for example intrinsic motivation, is connected to better outcomes than low-quality motivation, e.g., motivation through extrinsic rewards (e.g. Deci & Ryan, 1985; Ryan & Deci, 2020). Previous research largely supports a positive relationship between the use of serious games (Connolly et al., 2012; Kordaki & Gousiou, 2017; Vlachopoulos & Makri, 2017) or gamification (Dichev & Dicheva, 2017; Ekici, 2021; Koivisto & Hamari, 2019; Sailer & Homner, 2020) and motivational outcomes. However, some studies report contradictory results (e.g. Hamari et al., 2014; Hanus & Fox, 2015; Mekler et al., 2017; Sailer & Homner, 2020; Zimmerling et al., 2019). Beyond motivation, affect as a psychophysiological construct includes the dimensions of valence, an evaluation of the subjectively experienced state, and arousal, a measure of activation that can be considered as a proxy for motivation (Harmon-Jones et al., 2013). Further affective outcomes of gamification, serious games and game-based learning that can be attributed to the valence dimension include satisfaction (Boyle et al., 2016; Vlachopoulos & Makri, 2017) and positive attitudes towards the game (Vlachopoulos & Makri, 2017) or the gamified subject (Ekici, 2021), enjoyment (Ab Jalil et al., 2020; Koivisto & Hamari, 2019; Kordaki & Gousiou, 2017), immersion (Connolly et al., 2012) and flow (Koivisto & Hamari, 2019; Lamb et al., 2018).

Behavioral outcomes. In diverse contexts like education (Connolly et al., 2012; Jarnac de Freitas & Mira da Silva, 2020; Kordaki & Gousiou, 2017; Sailer & Homner, 2020; Vlachopoulos & Makri, 2017), employee training (Obaid et al., 2020), software development (Alhammad & Moreno, 2020), innovation (Patrício et al., 2018) or energy conservation (Johnson et al., 2017), motivating effects of gamification, serious games and game-based learning are consistently accompanied by positive behavioral outcomes. These include engagement and participation (Dichev & Dicheva, 2017; Ekici, 2021; Jarnac de Freitas & Mira da Silva, 2020), social collaboration and teamwork (Kordaki & Gousiou, 2017; Vlachopoulos & Makri, 2017) and measurable performance improvements in academic and work tasks (Bai et al., 2020; Koivisto & Hamari, 2019; Liu et al., 2018; McKeown et al., 2016). Because of these positive effects, gamification is increasingly adopted in various use cases to promote behavioral change, for example towards engagement in

pro-environmental behavior (e.g. Du et al., 2020; Ro et al., 2017), physical activity (e.g. Dadaczynski et al., 2017; Lier & Breuer, 2019) or knowledge transfer (e.g. Holzer et al., 2020; Mizuyama et al., 2019).

(Cognitive) learning outcomes. In addition, gamification, serious games and game-based learning contribute to a variety of learning outcomes (Behnamnia et al., 2020; Sailer & Homner, 2020; van Gaalen et al., 2021), most of which are cognitive in nature. Cognition can be understood as a set of processes and mechanisms by which an individual understands the world through reasoning and problem-solving (Lamb et al., 2018; Zimmerman & Croker, 2014). Studies report on significant improvements in critical thinking (Qian & Clark, 2016), creative thinking (Behnamnia et al., 2020; Qian & Clark, 2016), knowledge acquisition and content understanding (Connolly et al., 2012; Vlachopoulos & Makri, 2017) and perceptual skills (Connolly et al., 2012; Lamb et al., 2018; Vlachopoulos & Makri, 2017). However, certain mixed results on learning outcomes suggest that only the combination with affective and motivational outcomes leads to cognitive learning outcomes that result in successful academic performance improvement (Bai et al., 2020; Qian & Clark, 2016).

2.3. Theoretical foundations of gamification, serious games and game-based learning

As presented, considerable research efforts have already been made to investigate *whether* gamification leads to noticeable benefits, such as an increase in cognitive learning outcomes or work task performance, but there is still a lack of understanding regarding *how* gamification leads to these outcomes (Nacke & Deterding, 2017). Using conceptual propositions as a basis, such as the foundations of game-based learning in which Plass, Homer and Kinzer argue that various affective, motivational, cognitive and sociocultural foundations, e.g. situated learning theory (Brown et al., 1989; Lave & Wenger, 1991), achievement goal theory (Elliot & McGregor, 2001), social cognitive theory (Bandura, 1986) and activity theory (Vygotsky, 1978) provide the basis for the successful design of game-based learning (Plass et al., 2015), scientific studies have recently begun to employ theoretical foundations to design, explain and evaluate their gamified interventions. However, existing reviews do not fully display the diversity of the theories applied in different contexts. For example, Seaborn and Fels (2015) note the use of self-determination theory (Ryan & Deci, 2000b), situational relevance theory (Wilson, 1973) and the transtheoretical model of behavior change (Prochaska & Velicer, 1997) as prevalent foundations in primary gamification studies, whereas in contrast, Martí-Parreño et al. (2016) mention cognitive load theory (Sweller, 1988), the ARCS motivational model (Keller, 1987) and the technology acceptance model (Davis, 1989) as important theoretical foundations in gamification research. Dichev and Dicheva (2017), on the other hand, review gamification in the educational context and emphasize Lander's theory of gamified learning (Landers, 2014) as an important theoretical treatise in scientific studies, which includes self-determination theory, goal-setting theory (Locke, 1968; Locke & Latham, 2002) and behavior reinforcement theory (Skinner, 1957). Thus, regarding the theoretical foundations of gamification, serious games and game-based learning, these results illustrate the controversy and lack of an overview of the theories that are used as a basis for scientific research on gamification in different contexts, and about their implications for explaining the way gamification achieves the observed positive results.

In addition, there is a scarcity of research to explain certain mixed and conflicting results regarding the effects of game elements on motivational and affective, behavioral, and learning outcomes (e.g. Hamari et al., 2014; Mekler et al., 2017; Sailer & Homner, 2020; Zimmerling et al., 2019). For example, some studies display ambiguous results regarding effects on the focus group (e.g. Hanghøj et al., 2018) or the influence of specific gamification mechanics (e.g. Facey-Shaw et al., 2020). Accordingly, gamification does not seem to be a "silver-bullet type of solution" for achieving positive outcomes (Koivisto & Hamari, 2019, p. 201), and is not effective per se (Sailer et al., 2017). It is all the more important to understand the factors contributing to successful gamification, because in spite of the increasing adoption of theoretical foundations in research, they remain unresolved (Sailer & Homner, 2020). Insufficient knowledge about the psychological mechanisms through which gamification, serious games and game-based learning produce their effects (Cheng et al., 2015; Koivisto & Hamari, 2019; Sailer & Homner, 2020) hampers the selection of appropriate gamification structures, mechanics and principles to obtain the desired outcomes (Dichev & Dicheva, 2017). Although more recently, advances in explaining the impacts of certain gamification elements and designing gamification through the use of different theories have been made (Nacke & Deterding, 2017), further research synthesizing the principle assumptions of the theoretical foundations in use is crucial to understand how gamification, serious games and game-based learning can be designed in diverse contexts (Dichev & Dicheva, 2017; Sailer & Homner, 2020).

Therefore, this paper aims at answering the questions which theories have so far been used as foundations in research on gamification, serious games and game-based learning, how they relate to each other through core assumptions, and which basic principles can be derived that help explain how gamification achieves its effects.

3. Systematic review method

Systematic reviews give a methodical, replicable, and transparent overview over the complex field of literature to topics such as gamification. They provide an overall impression of the extent, nature and quality of evidence regarding the research question in focus. Thereby, they help to draw robust and broad implications for theory and future research (Siddaway et al., 2019). Meta-reviews, also called umbrella reviews, are reviews of existing reviews (Gough et al., 2017) and represent an appropriate methodological choice when there are already a large number of systematic reviews addressing the same or a very similar research question, with a concomitant increase in discordant findings (Paré et al., 2015). As explained, this is the case for existing reviews on theoretical foundations in gamification, serious games, and game-based learning. Specifically, the goal of a meta-review is to assemble the results of qualitative studies on a topic to locate core concepts or theories that provide new or stronger explanations for a particular phenomenon (Thorne et al., 2004) and to compile the available evidence on a specific research focus into a summary (Paré et al., 2015). Hence, we identified the method of a systematic meta-review as appropriate to answer the following primary research question by synthesizing the results of existing systematic literature reviews:

What are theoretical foundations used in research on gamification, serious games and game-based learning?

The review is conducted according to the ROSES Reporting standards for Systematic Evidence Syntheses, which advances the widely recognized PRISMA standard for meta-analyses from medical research (Moher et al., 2009), which focuses merely on quantitative data syntheses, into a new standard for narrative, qualitative and mixed methods syntheses (Haddaway et al., 2018).

Search strategy. For the identification of relevant literature, nine scientific databases were searched, namely the Web of Science Core Collection, EBSCO Host (APA PsychArticles, APA PsychInfo, Business Source Premier), Wiley Online, EmeraldInsight, ScienceDirect, JSTOR, SagePub, IEEE Explore and Taylor & Francis. The following search string was employed to gather review studies on gamification, serious games or game-based learning either in general or related to specific outcomes, i.e. affect, motivation, behavior or learning: *((“Gamification” OR “Serious Gaming” OR “Serious Games” OR “Game-based learning”) AND ((motivation* AND “theories”) OR (behavior* AND “theories”) OR (learning* AND “theories”) OR (affect* AND “theories”) OR “theoretical foundations” OR “theoretical perspectives” OR “theoretical frameworks” OR “theoretical approaches” OR (systematic* AND “review”) OR “meta-*

analysis")) OR "Gamification theories". The pluralistic version of *"theory"*, *"perspective"*, *"framework"* and *"approach"* has been used to exclude articles that mention only a single theoretical basis of their own work (e.g., a review of outcomes in game-based learning from a self-determination theory perspective) and to focus on review studies that systematically analyze theoretical underpinnings of multiple papers, since the main goal is to provide a comprehensive overview of the use of different theoretical foundations in scientific research. The search string was employed for title, abstract, and author keyword search, considering all articles published up to April 2021.

Screening strategy and inclusion criteria. According to the ROSES standard (Haddaway et al., 2018), the screening was carried out in three steps: Title screening, abstract screening, and full-text screening. To ensure research quality, only peer-reviewed journal articles and peer-reviewed conference papers were included in the final sample, while book chapters, not peer-reviewed journal articles and other grey literature were excluded. The reasons why conference papers were considered are that they account for a significant proportion of citations in computer science and research on human-computer interaction (Michels & Fu, 2014) and that the identification of articles from conference proceedings is generally recognized as good practice in systematic reviews (Scherer & Saldanha, 2019). Only English articles were included. Furthermore, the studies were included if they consisted of a systematic review or if they were a mixed-method study that contained a systematic review of scientific literature on gamification, serious gaming, or game-based learning, in which the theoretical foundations used in the reviewed sample were examined. Accordingly, empirical studies only referring to their own approach, reviews focusing on practical gamified applications such as smartphone apps or games, reviews on video games, and reviews only mentioning theories in their introduction or background but not examining the theoretical foundations of their sample studies or completely disregarding the theoretical perspective, were excluded during the screening process. The inclusion and exclusion criteria for the article screening are summarized in Table 1.

Critical appraisal strategy. For the critical appraisal of the reviewed studies, the following criteria were checked for each individual study:

1. Did the authors formulate at least one clear research question or research goal?
2. Did the authors describe their method for the systematic review?
   a. Search string(s)
   b. Search results
   c. Inclusion and exclusion criteria
   d. Number of included studies
3. Did the authors answer their research question(s)/goal(s) properly?

Table 1
Inclusion and exclusion criteria for the review on theoretical foundations in gamification research.

Criterion	Included	Excluded
Language	English	Other languages, e. g. Spanish, German, Russian, Korean, Chinese, Japanese
Publication type	Peer-reviewed journals, peer-reviewed conference papers	Book chapters, magazine articles, reports, theses, other grey literature
Type of study	Systematic literature review, mixed methods study containing a systematic literature review	Empirical studies, reviews of practical gamified applications or software
Study topic	Gamification, serious games, game-based learning	Video games
Study content	Examination of theoretical foundations used in the review sample	Theoretical foundations only mentioned in the introduction or background or not mentioned at all

Secondly, the publications were checked for their CORE journal rank, their Scientific Journal Ranking (SJR) and their Journal Impact Factor (JIF) to critically appraise the quality of the entire review sample.

Fig. 1 illustrates the result of the search strategy and the screening process. By applying the search string to the scientific databases, 973 records were identified, of which 915 remained through filtering for peer-reviewed articles and conference papers. After the duplicate removal, 627 records remained for screening. Of this sample, 246 records were excluded after the title screening, 195 records after the abstract screening and three full texts could not be retrieved so that 183 articles were considered for the full-text screening. During the full-text screening, 145 articles were excluded because they did not meet the specified inclusion criteria. This resulted in 38 articles remaining for critical appraisal, of which six articles were discarded due to lack of repeatability, as they either did not describe their literature search strategy (four studies) or lacked a definition of the inclusion and exclusion criteria (two studies). Every screening step was checked for consistency by the second author with at least 20 % of the respectively remaining sample, i.e., 125 for title screening, 76 for abstract screening, and 36 for full-text screening according to the inclusion criteria, and 19 of 38 remaining full texts were double-checked for critical appraisal. The intercoder agreement rate was 95,2 % for titles, 88,1 % for abstracts, 94,6 % for full-texts and 89,5 % for critical appraisal. Disagreements between the two coders were resolved through discussion and detailed further review of the disputed reviews. For reasons of reproducibility, the entire list of excluded full texts is attached in Appendix A. In summary, 32 reviews remained for data extraction and synthesis.

Data extraction strategy. Metadata such as title, year of publication, authors, publication type (journal or conference proceedings) and publication name of the articles were extracted with Mendeley Reference Manager and manually checked upon import. In addition, qualitative data extraction involved inductively encoding the application context of the review, the theoretical foundations mentioned in the review using abbreviations (the full coding list of abbreviations is attached in Appendix B) and summing up the number of studies applying a particular theoretical foundation, provided that the total number was given by the analyzed review. Although five of the reviews did not note the number of studies employing a particular theory, the popularity of different theoretical foundations could be assessed based on the available data, so that the missing data was not explicitly obtained from the review authors. Furthermore, a coding scheme for the classification of the identified theoretical foundations was developed based on the three main outcomes of gamification, i.e. affect and motivation, behavior and learning (attached in Appendix C), inspired by the distinction of previous reviews, the categorization of Plass et al. (2015) and Bloom's taxonomy (Bloom, 1956). 20 % of the reviews were double-coded by the second author, with an intercoder agreement rate of 85 % and Cohen's kappa $\kappa = 0.84775$ for the coding of the theoretical foundations and an intercoder agreement rate of 100 %, $\kappa = 1$ for the classification of the identified theoretical foundations. Any disagreements between the two coders were resolved through discussion and detailed joint review of the coded theoretical foundations in question.

4. Results

We first narratively report on the quality of the reviewed sample, the years of publication, the topics, and the application contexts of the reviewed articles, followed by the qualitative analysis of theoretical foundations mentioned in research on gamification, serious games and game-based learning.

4.1. Sample quality, topics, and application contexts

In critical appraisal of the sample's quality, it can be stated that all the reviews included were published in peer-reviewed journals, most of which are ranked highly in the Scientific Journal Ranking (SJR) and

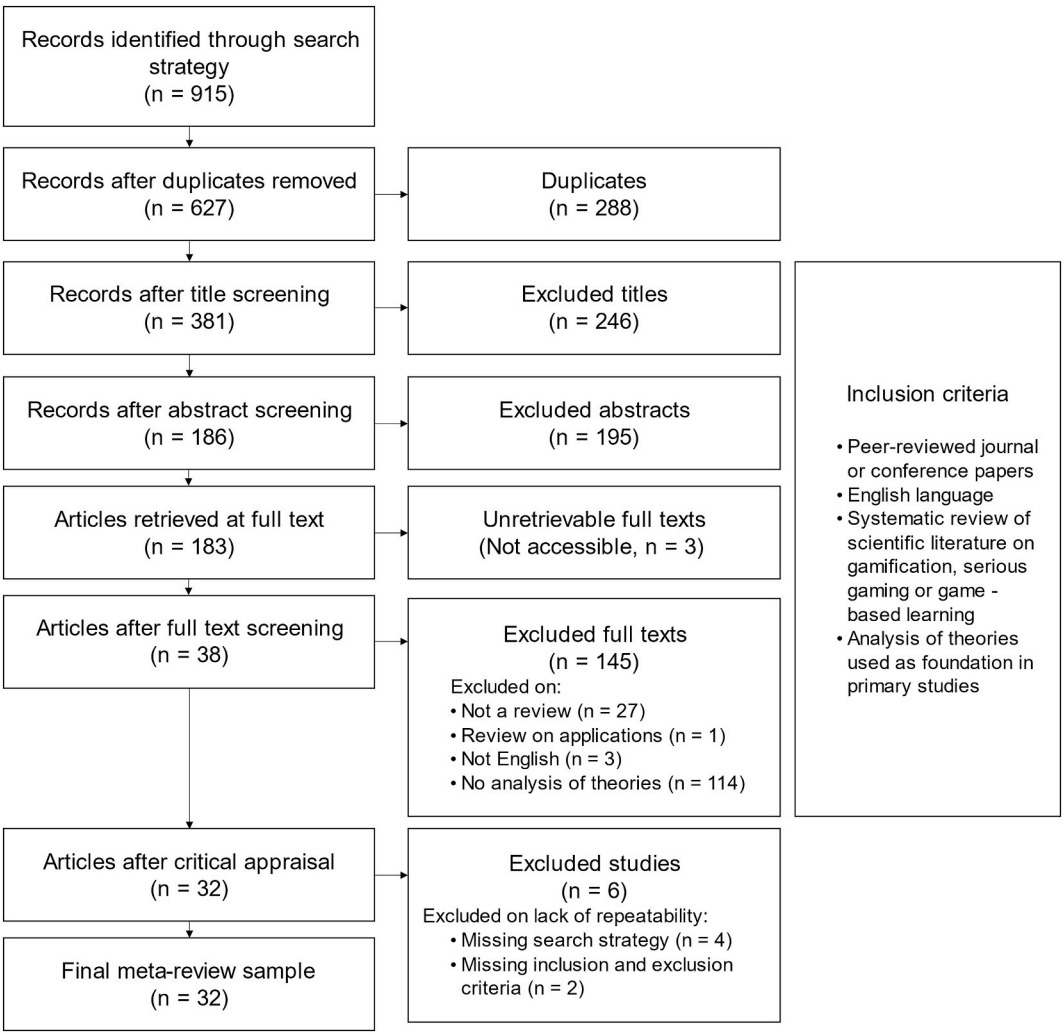

Fig. 1. Selection process: Flow diagram for the selection of studies in the systematic review on theoretical foundations in gamification research.

Journal Impact Factor (JIF). 18 of 32 reviews were published in the first quartile of their respective research area, mostly human-computer interaction, computer science, pedagogy, and psychology (see Table 2 for the comprehensive overview).

The first review explicitly mentioning theoretical foundations used in studies on serious games appeared in 2013 (Li & Tsai, 2013). Since then, the number of reviews analyzing the use of theory in empirical research demonstrates continuous scientific interest in the field of gamification, serious gaming, and game-based learning, with 12 of 32 reviews published in 2020 and 2021. Most of the reviews either focus on game-based learning or gamification in the application context of education (16 reviews). The second topic focus (8 reviews) consists of reviews on serious games, gamification and game-based learning in healthcare and fitness, followed by seven reviews on gamification, serious games and game-based learning in general, without a specific use case. In addition, one review dealt with gamification and online consumer decisions.

4.2. *Theoretical foundations in research on gamification and serious games*

This meta-review shows that empirical studies on gamification, serious games and game-based learning have so far used a variety of 118 different theories. Some theoretical foundations are considerably more popular than others, of which the most popular one (self-determination theory) is used in 82 different studies and the least popular ones are applied to only one study to date. Table 3 outlines all the theories mentioned in the analyzed reviews, together with the total number of primary research studies conducted based on each theory.

The theoretical foundations used originate from various theoretical research streams, including cognitive psychology, social psychology, and human-computer interaction. In the following, the identified theories are described and elaborated regarding their use in research on gamification, serious games and game-based learning. For further interest in the theoretical foundations, additional explanations of the theories and their origins are provided in Appendix D.

4.2.1. *Theoretical foundations with a focus on affect and motivation*

The first set of foundations focusing on affect and motivation is mainly concerned with *motivation* and *valence*, while arousal was not addressed in the identified theories.

Theories focusing on motivation deal with the mechanisms and determinants of motivation formation, such as the basic psychological needs – autonomy, competence and relatedness – from self-determination theory (Ryan & Deci, 2017) or self-efficacy, which describes a person's belief that they can successfully perform the required behavior (Bandura, 1982). Studies conclude that game mechanics partially (Frost et al., 2015; van Roy & Zaman, 2019) or fully (Xi & Hamari, 2019) address the basic needs for autonomy, competence and relatedness through elements such as customization which promote feelings of autonomy (Kim et al., 2015), achievements and badges that foster feelings of competence (Peng et al., 2012) or teams and social

Table 2
Journals and their ranking for the critical appraisal of the review sample.

Included reviews	Journal	CORE	JIF 2018	SJR H-Index	SJR Quartile
(Boyle et al., 2016; Kordaki & Gousiou, 2017)	Computers and Education	–	7.85	164	Q1
Zainuddin et al. (2020)	Educational Research Review	–	7.19	57	Q1
Qian and Clark (2016)	Computers in Human Behavior	–	5.88	155	Q1
Tobon et al. (2020)	Decision Support Systems	–	5.42	138	Q1
(Martí-Parreño et al., 2016; Wu et al., 2012)	Journal of Computer Assisted Learning	–	3.90	86	Q1
Chan et al. (2019)	PeerJ Computer Science	–	3.67	18	Q1
Chau et al. (2018)	International Journal of Medical Informatics	A	3.59	99	Q1
(Abraham et al., 2020; Thomas et al., 2020)	JMIR Serious Games	–	3.526	–	–
DeSmet et al. (2014)	Preventive Medicine	–	3.47	164	Q1
(Klock et al., 2020; Seaborn & Fels, 2015)	International Journal of Human-Computer Studies	A	3.16	116	Q1
Dichev and Dicheva (2017)	International Journal of Educational Technology in Higher Education	–	2.99	22	Q1
van Gaalen et al. (2021)	Advances in Health Sciences Education	–	2.75	60	Q1
Li and Tsai (2013)	Journal of Science Education and Technology	–	2.58	56	Q1
Mora et al. (2017)	Journal of Computing in Higher Education	–	2.46	31	Q1
Gao et al. (2020)	Education Technology Research and Development	–	2.30	84	Q1
Holtz et al. (2018)	Games for Health Journal	–	2.22	26	Q2
Behnamnia et al. (2020)	Thinking Skills and Creativity	–	2.07	36	Q1
Orji and Moffatt (2018)	Health Informatics Journal	C	1.90	37	Q2
Hallinger and Wang (2020a)	Simulation and Gaming	–	1.71	57	Q2
Bozkurt and Durak (2018)	International Journal of Game-Based Learning	–	1.43	15	Q2
Carenys and Moya (2016)	Accounting Education	–	1.38	35	Q2
Kalogiannakis et al. (2021)	Education Sciences	–	1.19	7	Q3
Jarnac de Freitas & Mira da Silva (2020)	Open Learning	–	1.03	33	Q2
Ab Jalil et al. (2020)	International Journal of Emerging Technologies in Learning	–	1.00	19	Q3
da Silva et al. (2019)	BAR - Brazilian Administration Review	–	0.40	14	Q4
Bakan and Bakan (2018)	Actualidades Pedagogicas	–	–	–	–
		–	–	–	–
Gris and Bengtson (2021)	International Journal of Serious Games	–	–	2	–
Cheng et al. (2015)	Journal of Computers in Education				

networks that enhance feelings of relatedness (Xi & Hamari, 2019). Gamification and serious games also increase self-efficacy, e.g., for reacting in emergencies (Chittaro & Buttussi, 2018), identifying cyber-security threads (Baral & Arachchilage, 2019) and performing learning tasks (Blasko-Drabik et al., 2013). Related to self-efficacy theory, social comparison theory emphasizes the natural urge to assess oneself in comparison with others (Festinger, 1954), which can be perceived as motivating or discouraging depending on circumstances (Buunk & Gibbons, 2007). For example, social comparisons in form of leaderboards or social status elements can have different effects in different samples (Christy & Fox, 2014).

Flow theory presents flow as a *"holistic sensation that people feel when they act with total involvement"* (Csikszentmihalyi, 1975, p. 36). Although flow is inherently valent, it is closely related to motivation: when individuals are fully engaged in an activity, they experience the activity as intrinsically rewarding and pursue it for the sake of the activity itself rather than to achieve the ultimate goal (Csikszentmihalyi, 2014). However, the impact of gamification and serious games on flow experiences has not yet been clearly established (Almeida & Buzady, 2019; Bitrián et al., 2020; Catalán et al., 2019; Chung et al., 2019).

Other theories address both motivation and valence, describing the effect of predictors such as expectations and values, as included in the ARCS model of motivation for instructional design, which states that motivation is the result of a combination of four factors – attention, relevance, confidence and satisfaction (Keller, 1987; Porter & Lawler, 1968). Satisfaction as a valent determinant of motivation depends on outcome expectations, such as goals, while confidence refers to personal belief in success, i.e., self-efficacy (Keller, 1979). Similarly, goal-setting theory (Locke, 1968) and achievement goal theory (Nicholls, 1984) emphasize the importance of goals for motivational mechanisms and the importance of satisfaction with goal achievement for commitment to further goals (Locke & Latham, 2002, 2013). While the ARCS questionnaire is often used to quantitatively evaluate the motivational effect of serious games and game-based learning on the four factors, with positive to mixed results (e. g. Kaneko et al., 2015; Deif, 2017; Calvo-Ferrer, 2018; Ozdamli, 2018), possibly due to its pedagogical focus, the latter, i.e. goal-setting and achievement goal theory, are used predominantly to refine and improve gamified interventions, e.g. with leaderboards as goal-setting mechanisms (e. g. Chernbumroong et al., 2017; Landers et al., 2017; Nebel et al., 2017), and the individualization to achievement goal orientations with various game elements such as feedback, progress bars, leaderboards and badges (e. g. Roosta & Taghiyareh, 2016).

4.2.2. *Theoretical foundations with a focus on behavior*

Second, there are a variety of theoretical foundations that describe the determinants of *behavioral* outcomes.

Reinforcement theory, the most prominent example of radical behaviorism (Moore, 2011), considers the cognitive processes of behavior formation as a "black box" and suggests direct relationships between stimuli and outcomes (Skinner, 1953). It primarily guides the study of whether extrinsic gamification mechanics, such as rewards (Berkovsky et al., 2012; Kordaki & Gousiou, 2017) or climbing the leaderboard (Huang et al., 2019), can positively influence learning outcomes.

Table 3
Theoretical foundations mentioned in the analyzed review studies.

Theoretical foundation	Reviews mentioning theory	Sum of studies using theory
Self-determination theory	(Ab Jalil et al., 2020; Bakan & Bakan, 2018; Behnamnia et al., 2020; Bozkurt & Durak, 2018; Chan et al., 2019; Chau et al., 2018; da Silva et al., 2019; Dichev & Dicheva, 2017; Gris & Bengtson, 2021; Jarnac de Freitas and Mira da Silva, 2020; Kalogiannakis et al., 2021; Mora et al., 2017; Orji & Moffatt, 2018; Seaborn & Fels, 2015; Thomas et al., 2020; Tobon et al., 2020; Zainuddin et al., 2020)	82
Flow theory	(Ab Jalil et al., 2020; Bakan & Bakan, 2018; Behnamnia et al., 2020; Bozkurt & Durak, 2018; Cheng et al., 2015; da Silva et al., 2019; Gao et al., 2020; Gris & Bengtson, 2021; Hallinger & Wang, 2020a; ; Kalogiannakis et al., 2021; Jarnac de Freitas and Mira da Silva, 2020; Mora et al., 2017; Qian & Clark, 2016; Tobon et al., 2020; Zainuddin et al., 2020)	47
Experiential learning theory	(Abraham et al., 2020; Bakan & Bakan, 2018; Gao et al., 2020; Hallinger & Wang, 2020a; Li & Tsai, 2013; Qian & Clark, 2016; van Gaalen et al., 2021; Wu et al., 2012)	40
Constructivist learning theory	(Behnamnia et al., 2020; Carenys & Moya, 2016; Cheng et al., 2015; Hallinger & Wang, 2020a; Kordaki & Gousiou, 2017; Li & Tsai, 2013; Qian & Clark, 2016; Zainuddin et al., 2020)	31
Cognitive load theory	(Ab Jalil et al., 2020; Bakan & Bakan, 2018; Bozkurt & Durak, 2018; Cheng et al., 2015; Gris & Bengtson, 2021; Li & Tsai, 2013; Martí-Parreño et al., 2016; Zainuddin et al., 2020)	24
Social cognitive theory	(Abraham et al., 2020; Bozkurt & Durak, 2018; Chau et al., 2018; DeSmet et al., 2014; Gris & Bengtson, 2021; Holtz et al., 2018; Li & Tsai, 2013; Orji & Moffatt, 2018)	16
Situated learning theory	(Bakan & Bakan, 2018; Cheng et al., 2015; Gao et al., 2020; Hallinger & Wang, 2020a; Li & Tsai, 2013; Qian & Clark, 2016; Wu et al., 2012)	29
Sociocultural theory of cognitive development	(Bakan & Bakan, 2018; Cheng et al., 2015; Gao et al., 2020; Kordaki & Gousiou, 2017; Li & Tsai, 2013; Wu et al., 2012; Zainuddin et al., 2020)	23
Technology acceptance model	(Boyle et al., 2016; Bozkurt & Durak, 2018; Carenys & Moya, 2016; Martí-Parreño et al., 2016; Mora et al., 2017; Orji & Moffatt, 2018; Tobon et al., 2020)	13
Theory of planned behavior	(Ab Jalil et al., 2020; Bozkurt & Durak, 2018; Chau et al., 2018; da Silva et al., 2019; DeSmet et al., 2014; Orji & Moffatt, 2018; Tobon et al., 2020)	10
Reinforcement theory	(Carenys & Moya, 2016; Dichev & Dicheva, 2017; Kordaki & Gousiou, 2017; Orji & Moffatt, 2018; van Gaalen et al., 2021; Zainuddin et al., 2020)	9
Social learning theory	(Abraham et al., 2020; Bozkurt & Durak, 2018; Hallinger & Wang, 2020a; Holtz et al., 2018; Orji & Moffatt, 2018; Wu et al., 2012)	8
ACRS model	(Boyle et al., 2016; Bozkurt & Durak, 2018; Carenys & Moya, 2016; Gris & Bengtson, 2021; Martí-Parreño et al., 2016)	14
Transtheoretical model of behavior change	(Bozkurt & Durak, 2018; Chau et al., 2018; Orji & Moffatt, 2018; Seaborn & Fels, 2015)	19
Activity theory	(Cheng et al., 2015; Li & Tsai, 2013; Qian & Clark, 2016; Wu et al., 2012)	14
Goal-setting theory	(Dichev & Dicheva, 2017; Kalogiannakis et al., 2021; Orji & Moffatt, 2018; Zainuddin et al., 2020)	10
Theory of reasoned action	(Bozkurt & Durak, 2018; Chau et al., 2018; Orji & Moffatt, 2018; Zainuddin et al., 2020)	6
Problem-based learning[a]	(Bakan & Bakan, 2018; Li & Tsai, 2013; Wu et al., 2012)	29
Multimedia learning theory	(Cheng et al., 2015; Kalogiannakis et al., 2021; Li & Tsai, 2013)	10
Achievement goal theory	(Ab Jalil et al., 2020; Gris & Bengtson, 2021; Klock et al., 2020)	5
Self-efficacy theory	(Bozkurt & Durak, 2018; Chan et al., 2019; Zainuddin et al., 2020)	4
Social comparison theory	(Tobon et al., 2020; van Gaalen et al., 2021; Zainuddin et al., 2020)	4
Discovery learning theory	(Bakan & Bakan, 2018; Wu et al., 2012)	16
Case-based learning[b]	(Bakan & Bakan, 2018; Wu et al., 2012)	12
Mechanics, dynamics and aesthetics framework	(Bozkurt & Durak, 2018; Mora et al., 2017)	11
Stage theory of cognitive development	(Bakan & Bakan, 2018; Wu et al., 2012)	10
Digital game-based learning[c]	(Bozkurt & Durak, 2018; Gao et al., 2020)	6
User-centered design[d]	(Mora et al., 2017; Seaborn & Fels, 2015)	4
Cognitive evaluation theory	(Bozkurt & Durak, 2018; Zainuddin et al., 2020)	4
Uses and gratifications theory	(Ab Jalil et al., 2020; Qian & Clark, 2016)	4
Gagné's instruction strategies[e]	(Thomas et al., 2020; Wu et al., 2012)	4
Fogg's behavior model	(Bozkurt & Durak, 2018; Zainuddin et al., 2020)	3
Theory of motivation, volition and performance	(Boyle et al., 2016; Carenys & Moya, 2016)	3
Situational relevance theory	(Mora et al., 2017; Seaborn & Fels, 2015)	2
Theory of multiple intelligence	(Gao et al., 2020; Li & Tsai, 2013)	2
Immersion theory	(Gao et al., 2020; Gris & Bengtson, 2021)	2
Transportation theory	(DeSmet et al., 2014; Thomas et al., 2020)	1
Lander's theory of gamified learning	(da Silva et al., 2019; Zainuddin et al., 2020)	1
Health belief model	(DeSmet et al., 2014; Orji & Moffatt, 2018)	1
Direct instruction[f]	Wu et al. (2012)	9
Elaboration theory	Wu et al. (2012)	7
	Bozkurt and Durak (2018)	4

(*continued on next page*)

Table 3 (*continued*)

Theoretical foundation	Reviews mentioning theory	Sum of studies using theory
User-centered theoretical framework for meaningful gamification		
Constructionism	Qian and Clark (2016)	4
Cognitive apprenticeship	Wu et al. (2012)	4
Inquiry-based learning[g]	Gao et al. (2020)	4
Programmed instruction[h]	Wu et al. (2012)	3
Social conformity theory[i]	Orji and Moffatt (2018)	3
Information, motivation and behavior model	Abraham et al. (2020)	3
Interest theory of learning	Li and Tsai (2013)	2
Theory-driven gamification design model	Zainuddin et al. (2020)	2
Unified theory of acceptance and use of technology	Orji and Moffatt (2018)	2
Malone's theory	Carenys and Moya (2016)	2
Taxonomy of behavior change techniques	Thomas et al. (2020)	2
Maslow's hierarchy of needs	Bozkurt and Durak (2018)	2
Diffusion of innovation theory	Bozkurt and Durak (2018)	2
Theory of organizational behavior	Bozkurt and Durak (2018)	2
Situational interest theory	Chan et al. (2019)	2
Mood management theory	Ab Jalil et al. (2020)	2
Communication theory	Ab Jalil et al. (2020)	2
Theory of affordances	Behnamnia et al. (2020)	2
Guilford's structure of intellect	Behnamnia et al. (2020)	2
Model model	Behnamnia et al. (2020)	2
Moran's theorem	Behnamnia et al. (2020)	2
Attribution theory	Wu et al. (2012)	2
Actor-network theory	Wu et al. (2012)	1
Wisom, intelligence and creativity synthesized theory	Behnamnia et al. (2020)	1
Play, affect and creativity theory	Behnamnia et al. (2020)	1
Self-directed learning theory	van Gaalen et al. (2021)	1
Expectancy-value theory	Dichev and Dicheva (2017)	1
Theory of gamified instructional design	Dichev and Dicheva (2017)	1
Ego depletion theory	Orji and Moffatt (2018)	1
Parallel process model	Orji and Moffatt (2018)	1
Theory of meanings of behavior	Orji and Moffatt (2018)	1
Knowledge, attitude, behavior model	Orji and Moffatt (2018)	1
Premack's principle	Orji and Moffatt (2018)	1
Big five personality theory	Orji and Moffatt (2018)	1
Sexual health model	Orji and Moffatt (2018)	1
Narrative centered learning[j]	Qian and Clark (2016)	1
Deliberate practice[k]	van Gaalen et al. (2021)	1
Social network theory	Chau et al. (2018)	1
Theory of interactive technology	Chau et al. (2018)	1
Transcontextual model of motivation	Chau et al. (2018)	1
Control theory	Chau et al. (2018)	1
Information systems success model	Zainuddin et al. (2020)	1
Presence pedagogy model	Zainuddin et al. (2020)	1
Eisenkraft's 7E instructional model	Zainuddin et al. (2020)	1
Felder-Silverman learning style model	Zainuddin et al. (2020)	1
Merrill's principles of instruction design theory	Zainuddin et al. (2020)	1
Technology-enhanced training effectiveness model	Zainuddin et al. (2020)	1
Unified modeling language[l]	Zainuddin et al. (2020)	1
Rational choice theory	Zainuddin et al. (2020)	1
Mechanics, dynamics and emotions model	Mora et al. (2017)	1
Moral design framework	Mora et al. (2017)	1

Table 3 (*continued*)

Theoretical foundation	Reviews mentioning theory	Sum of studies using theory
Organismic integration theory	Mora et al. (2017)	1
Four drives theory	Mora et al. (2017)	1
Person-artefact-task model	Mora et al. (2017)	1
Affect transfer theory	Ab Jalil et al. (2020)	1
Cognitive dissonance theory	Ab Jalil et al. (2020)	1
Middle-range theory of chronic illness	Abraham et al. (2020)	1
Adult learning theory	Abraham et al. (2020)	1
Murray's secondary psychological needs	Klock et al. (2020)	1
Situative embodiment[m]	Li and Tsai (2013)	1
Transformational play[n]	Li and Tsai (2013)	1
Prediction-observation-explanation model	Li and Tsai (2013)	1
Enactivism	Li and Tsai (2013)	1
Behavioral economics[o]	Thomas et al. (2020)	1
Dual-task training[p]	Thomas et al. (2020)	1
Gee's game-based learning principles[q]	Gao et al. (2020)	1
Tripartite enjoyment model	Gris and Bengtson (2021)	1
Universal design for learning	Seaborn and Fels (2015)	1
Scientific discovery as dual search model	Qian and Clark (2016)	1
Werbach's gamification framework	Gao et al. (2020)	1
Embodied learning[r]	Gao et al. (2020)	1
Taxonomy of intrinsic motivations for learning	Gao et al. (2020)	1
Theory of realistic mathematics education	Gao et al. (2020)	1
Theory of motivation to learn[s]	Kalogiannakis et al. (2021)	1
Elaboration likelihood model	DeSmet et al. (2014)	–
Taxation theory	Zainuddin et al. (2020)	–

[a] Problem-based learning is not a theory, but a specific paradigm of instructional design related to constructivist learning. It is therefore excluded in the further analysis.

[b] Case-based learning is not a theory, but a specific paradigm of instructional design related to constructivist learning. It is therefore excluded in the further analysis.

[c] Bozkurt and Durak (2018) note digital game-based learning as a theoretical foundation, but the term describes a whole research field within gamification and serious gaming rather than a specific theory, so it is excluded in the further analysis.

[d] User-centered design is not a theory, but much more a paradigm of tailoring the design process around the user's needs and expectations. It is therefore excluded in the further analysis.

[e] Gagnés instruction strategies or principles are not a theory, but guidelines for instructional design. They are therefore excluded in the further analysis.

[f] Direct instruction is not a theory, but a specific instructional method related to behaviorism. It is therefore excluded in the further analysis.

[g] Inquiry-based learning is not a theory, but a specific paradigm of instructional design. It is therefore excluded in the further analysis.

[h] Programmed instruction is not a theory, but a specific instructional method related to behaviorism. It is therefore excluded in the further analysis.

[i] Orji and Moffatt (2018) claim that social conformity theory was used in three of the studies they analyzed, but further investigation revealed that the studies cited only used the concept of the importance of social influence and pressure in designing their interventions, rather than referring to a specific theoretical foundation, model or framework. Since subsequent searches did not reveal gamification or serious gaming studies using such a theory, it is excluded in the further analysis.

[j] Narrative-centered learning is not a theory for itself, but the realization of instruction strategies grounded in transportation theory. It is therefore excluded in the further analysis.

[k] Deliberate practice describes a paradigm of learning with purposeful repetition, but it is not a learning theory. Therefore, it is excluded in further analysis.

[l] The Unified Modeling Language (UML) is not a theoretical foundation. It was mentioned by Zainuddin et al. (2020) because it was used in the original study as the teaching content of their gamified intervention and is listed here for the sake of completeness but excluded in the further analysis.

[m] Situative embodiment is a central concept in the phenomenological school of thought, but not a specific theory. Therefore, it is excluded in further analysis.

[n] Transformational play is a form of play to promote creativity, innovation, empowerment and social connection, but it is not a theory and therefore excluded in further analysis.

[o] Behavioral economics is a specific discipline within economic science and includes a variety of different theories, such as prospect theory and nudge theory. However, Thomas et al. did not specify the theory used in the primary study, and further investigation of the primary study did not lead to the identification of a specific theory either. Therefore, behavioral economics is excluded in the further analysis.

[p] Dual-task training is not a theory, but a training method. It is therefore excluded in the further analysis.

[q] Gee's game-based learning principles are useful for the design of game-based learning, but they rather constitute recommendations than theory. Therefore, they are excluded in the further analysis.

[r] Embodied learning is not a theory, but a specific instructional method. It is therefore excluded in the further analysis.

[s] The theory of motivation to learn was mentioned as a theoretical foundation in the review of Kalogiannakis, Papadakis and Zourmpakis, but they do not mention the specific primary study using this foundation. As a detailed search could not identify such a theory, it is excluded in the further analysis.

Other theories focusing on behavior, such as the theory of reasoned action (Ajzen & Fishbein, 1980), the theory of planned behavior (Ajzen, 1991) and the technology acceptance model (Davis et al., 1989), outline the importance of behavioral attitudes and subjective norms on behavioral intention, which then leads to actual behavior. In addition, as an extension of the theory of reasoned action, the theory of planned behavior adds perceived behavioral control as a determinant of behavioral intention (Ajzen, 1991), which is closely related to the motivational concept of self-efficacy (Ajzen, 2002), while as a second extension of the theory of reasoned action tailored to user acceptance of information systems, the theory of planned behavior adds perceived usefulness and perceived ease of use as determinants of behavioral attitude (Davis et al., 1989). All three theories serve as a basis to assess the impact of gamification on the determinants (behavioral attitude, subjective norms and perceived behavioral control) and thus on behavioral intentions, such as the intention to adopt solar energy (Rai & Beck, 2017), choose sustainable means of transport (Andersson et al., 2018), or make a purchase (Bittner & Shipper, 2014). In the case of the technology acceptance model, the framework is also used to evaluate the acceptance of gamified interventions, e.g., whether they perform well in terms of perceived usefulness and perceived ease of use, thereby generating positive attitudes and behavioral intent to use (e. g. Bourgonjon et al., 2013; Siala et al., 2019; Vanduhe et al., 2020).

Furthermore, two theories describe the process of behavior change (Prochaska & Diclemente, 1982) and the cognitive system in which human actions are influenced by rules, culture and the community, called the activity system (Engeström, 1987; Vygotsky, 1978). These theories are not used for evaluation, but for the design of gamified systems and serious games. They are either based on the stages of the transtheoretical model to promote changes towards healthy behavior (Alsaleh & Alnanih, 2020; Bahia et al., 2014) and sustainable behavior (AlSkaif et al., 2018; Andersson et al., 2018), e.g., by focusing on the provision of information in the early stages and shifting to elements of social pressure and performance tracking mechanisms in the later stages (AlSkaif et al., 2018; Andersson et al., 2018), or based on the activity system with the game as a mediating instrument (e. g. De Freitas & Oliver, 2006; Carron et al., 2008; Ellahi et al., 2017; Calvo & Reio, 2018; Charrouf & Taha Janan, 2019).

4.2.3. Theoretical foundations with a focus on learning

The third category of theoretical foundations deals with determinants and processes of *learning*. Most of these theories originate from social psychology, e.g. social learning theory (Bandura, 1971), social cognitive theory (Bandura, 2001a,b), and the sociocultural theory of cognitive development (Vygotsky, 1978), and describe the crucial role of sociocultural influences and interactions in successful learning processes. A central concept in social learning theory and social cognitive theory, which is an extension of social learning theory, is that of *vicarious learning*, that is, learning by observing others (Bandura, 1971). This concept guides the design of game-based learning interventions, e. g. by introducing mechanisms that enable social observation processes (Jeen et al., 2007) or by designing role model game characters (Fuchslocher et al., 2011) for vicarious learning (Amresh et al., 2019; Bowen et al., 2014; Bul et al., 2015). In turn, sociocultural theory of cognitive development introduces the idea of the *Zone of Proximal Development*, i. e., the distance between the actual level of development and the level of potential development that can be acquired through guidance, peer cooperation, or instruction (Vygotsky, 1978). Gamification and serious games based on sociocultural theory are adaptive and individualized in design to scaffold the learners within their zones of proximal development (e.g. Davis et al., 2018; Rachels & Rockinson-Szapkiw, 2018).

Constructivist learning theory (Jonassen, 1999; Piaget, 1977) addresses the general process of knowledge construction and the initialization of learning processes, incorporating motivational aspects as crucial preconditions for successful learning. On this basis, the inclusion of constructivist principles in gamified applications such as experiential learning, participation and self-reflection (e. g. Huebscher & Lendner, 2010; Avramenko, 2012; Kordaki & Gousiou, 2017) aims to improve desired learning outcomes. In this context, experiential learning theory emphasizes that knowledge is acquired through personal and environmental experiences rather than through instruction and in an iterative learning cycle (Kolb, 1984). Relatedly, situated learning theory states that conceptual knowledge cannot be abstracted from the situations in which it is learned and used (Brown et al., 1989). Hence, learning environments need to be designed in such an authentic way that students can learn by linking their prior knowledge to real-world scenarios as they participate in the learning activities (Hwang et al., 2015). Accordingly, both experiential learning theory and situated learning theory guide the design of virtual environments in serious games to resemble real-world environments and problem-solving contexts (e.g. All et al., 2017; Hou, 2015; Hou & Li, 2014) to allow for experience, observation and experimentation (e.g. Furió et al., 2013; Verkuyl et al., 2017; Wrzesien & Alcañiz Raya, 2010).

Finally, cognitive load theory (Sweller, 1988) and multimedia learning theory (Mayer, 2005) are concerned with mental processing capacity and the different mental processes involved in organizing and linking learning content to prior knowledge. Extraneous processing or extraneous cognitive load in this context represent cognitive processes that distract from active processing of learning content (Mayer, 2005; Sweller, 1988). Both theoretical bases open up scientific discussions on whether serious games, game-based learning and gamification can be designed to reduce the extraneous cognitive load or if they increase cognitive load and thus cause counterproductive effects on learning (e.g. Adams & Clark, 2014; Brom et al., 2019; Deleeuw & Mayer, 2011; Johnson & Mayer, 2010; Moreno & Mayer, 2005).

4.2.4. Other theoretical foundations

Scientists have used a variety of other theoretical foundations of secondary importance, i.e., they were only mentioned by one or two reviews, from different disciplines. Some of them aim to propose guidelines for system design, such as the mechanics, dynamics and aesthetics model (Hunicke, LeBlanc, & Zubek, 2004), the user-centered theoretical framework for meaningful gamification (Nicholson, 2012), or Werbach's gamification framework (Werbach, 2014) . They are used for gamification design in a variety of scientific studies (e. g. Angelia & Suharjito, 2019; Arnab & Clarke, 2017; Constantinescu et al., 2017; Dietrich et al., 2018; Stansbury & Earnest, 2017). In addition, the theoretical foundations originate from management research, such as theories of organizational behavior (e. g. Mayo, 1933) or the diffusion of innovations theory (Rogers, 1962), but also medicine (Sexual Health

Model, Robinson, 2015) and personality (Big Five, Allport & Odbert, 1936). Table 4 illustrates the classified theoretical foundations according to their thematic focus and popularity in research on gamification, serious games and game-based learning.

5. Discussion

This systematic review aimed to identify theoretical foundations in gamification, serious games, and game-based learning research. We identified 118 different theoretical foundations that are used to design and evaluate gamified interventions, and that help explain how gamification, serious games and game-based learning achieve their desired (motivational and affective, behavioral, and learning) effects. Although the overview of these theories already represents a valuable contribution to further research on the underlying mechanisms of gamification, we have also observed notable relationships that unify several of the theories presented. Moving from an observative to an explanatory level, the discussion of the commonalities between the theoretical foundations serves to identify their core assumptions to gain a more comprehensive understanding of how gamification works. Fig. 2 shows the relationships between the theoretical foundations most widely used in research on gamification, serious games and game-based learning, which are further elaborated below. Each theory is presented as a bubble scaled according to the relative popularity of the theoretical foundation as identified in the systematic review. The bubbles are color-coded according to their thematic focus (motivation and affect, behavior or learning, see also Appendix C). As shown, some theories are marked with mixed color, indicating that their thematic focus is not clearly distinguishable. Straight arrows represent explicitly mentioned inclusions of one theory into another by the developing scientists. All the above-mentioned relations are objectively derived from the results of the systematic review. In addition, dashed lines indicate relationships concerning the main assumptions of two theories that we hypothesize based on our detailed analysis.

According to goal-setting theory, goals must fulfill the criteria of both specificity and difficulty for them to be motivating (Locke, 1968). From a motivational perspective, clear goals also support the emergence of flow experiences (Csikszentmihalyi, 2014; Csikszentmihalyi & Csikszentmihalyi, 1988), which are directly related to the concept of intrinsic motivation as articulated in self-determination theory (Ryan & Deci, 2000b): when individuals are fully involved in an activity, they experience the activity as intrinsically rewarding, and pursue it for the sake of the activity itself (Csikszentmihalyi, 2014). The ARCS model posits that clear goals represent major outcome expectations that particularly drive motivation when they are perceived as relevant and achievable (Keller, 1987). From a self-determination view, clear goals support the need for competence, while relevant goals support the need for autonomy (Ryan & Deci, 2000b). Also from a constructivist learning perspective, demonstrating and articulating the relevance of a goal is critical to supporting successful knowledge construction (Jonassen, 1999). Behavioral theories such as the theory of reasoned action (Ajzen, 1985) and the theory of planned behavior (Ajzen, 1991) add that clear and relevant goals as outcome expectations promote a positive behavioral attitude, which then leads to behavioral intention and the actual desired behavior. Gamification and serious games can be valuable tools for illustrating goals and their relevance through elements such as badges and achievements, which have been shown to work similarly to classical goal-setting mechanisms (Gutt et al., 2020) and even improve performance compared to classical goal-setting (Groening & Binnewies, 2019). The introduction of challenges, sometimes called quests (Klock et al., 2020), can also serve as a goal mechanism (Laine & Lindberg, 2020), whereby the overarching goals are playfully broken down into specific sub-goals. Similarly, a predefined level system can provide students with goals to achieve (Ding et al., 2020). Especially in game-based learning and serious games, stories or narratives can further reinforce the communication of specific learning goals (Nebel et al.,

Table 4
Classified theoretical foundations in research on gamification, serious games and game-based learning.

Affect and Motivation	Behavior	Learning	Other
Prevalent theories (mentioned at least three times)			
Self-determination theory	Technology acceptance model	Experiential learning theory	
Flow theory	Theory of planned behavior	Constructivist learning theory	
ARCS model	Reinforcement theory	Cognitive load theory	
Goal-setting theory	Transtheoretical model of behavior change	Social cognitive theory	
Self-efficacy theory	Theory of reasoned action	Situated learning theory	
Social comparison theory	Activity theory	Sociocultural theory of cognitive development	
Achievement goal theory		Social learning theory	
		Multimedia learning theory	
Other theories (mentioned less than three times)			
Cognitive evaluation theory	Fogg's behavior model	Discovery learning theory	Mechanics, dynamics and aesthetics framework
Health belief model	Information, motivation and behavior model	Stage theory of cognitive development	Uses and gratifications theory
Situational relevance theory	Unified theory of acceptance and use of technology	Theory of motivation, volition and performance	Theory of multiple intelligence
Immersion theory	Model	Elaboration theory	Theory-driven gamification design model
Transportation theory	Rational choice theory	Constructionism	User-centered theoretical framework for meaningful gamification
Organismic integration theory	Ego depletion theory	Interest theory of learning	Control theory
Four drives theory	Parallel process model	Cognitive apprenticeship	Elaboration likelihood model
Person-artefact-task model	Theory of meanings of behavior	Universal design for learning	Taxation theory
Maslow's hierarchy of needs	Knowledge, attitude, behavior model	Presence pedagogy model	Diffusion of innovation theory
Murray's secondary psychological needs	Social network theory	Eisenkraft's 7E instructional model	Theory of organizational behavior
Transcontextual model of motivation	Premack's principle	Felder-Silverman learning style model	Communication theory
Situational interest theory		Merrill's principles of instruction design theory	Theory of affordances
Attribution theory		Technology-enhanced training effectiveness model	Moran's theorem
Expectancy-value theory		Malone's theory	Guildford's structure of intellect
Affect transfer theory		Lander's theory of gamified learning	Big five personality theory
Mood management theory		Theory of gamified instructional design	Sexual health model
Cognitive dissonance theory		Adult learning theory	Information systems success model
Play, affect and creativity theory		Theory of realistic mathematics education	Mechanics, dynamics and emotions model
Taxonomy of intrinsic motivations for learning		Prediction-observation-	Theory of interactive technology
Tripartite enjoyment model			Moral design framework

(continued on next page)

Table 4 (*continued*)

Affect and Motivation	Behavior	Learning	Other
		explanation model Scientific discovery as dual search model Self-directed learning theory	Middle-range theory of chronic illness Wisdom, intelligence and creativity synthesized theory Werbach's gamification framework Enactivism Actor-network theory

2017) and chain goals together in an exciting story (Rapp, 2017b). From this, we derive the first principle of how gamification works:

P1: Clear and relevant goals. *Gamification can transparently illustrate goals and their relevance.*

Self-determination theory includes several sub-theories such as cognitive evaluation theory, organismic integration theory and basic psychological needs theory, and distinguishes between amotivation and different types of extrinsic and intrinsic motivation (Ryan & Deci, 2000b). A specific sub-theory of self-determination theory is goal-contents theory (Ryan & Deci, 2017), which states that people have different foci in pursuing intrinsic and extrinsic aspirations or goals. This is similar to the main assumptions of achievement goal theory, which also suggests that individuals exhibit a mixture of achievement orientations in pursuit of goals (Elliot, 1999; Elliot & McGregor, 2001). Thus, to promote the relevance of a particular intervention to subjects, individuals should be given the opportunity to set goals for themselves, which supports their need for autonomy (Ryan & Deci, 2000b) and, according to goal-setting theory, promotes positive affective responses to the goal, these being an important moderator of the goal-performance relationship (Locke & Latham, 2002, 2013). Social cognitive theory adds that the opportunity to set one's own goals is essential for self-regulation in learning (Bandura, 2001a,b). Gamification research has emphasized that leaderboards are a main element for users to strive for their own goals (Chernbumroong et al., 2017; Landers et al., 2017). Furthermore, in game-based learning, customizable learning journeys with "level bosses" that must be defeated for each milestone achieved have been shown to support users in self-goal setting and thus self-regulated learning (Chen et al., 2019). In addition, showing avatars that represent the user's future and ideal image can effectively serve as a role model for self-improvement of offline behaviors, such as a healthy lifestyle (Rapp, 2017a). Performance stats and tracking features of gamified systems may also support users in self-monitoring processes for self-defined goals, especially related to diet, exercise, or medication (Al-Ramahi et al., 2016). Thus, we derive the following principle of how gamification works:

P2: Individual goals. *Gamification can allow users to set their own goals.*

The need for competence as one of the three basic psychological needs mentioned in self-determination theory is strongly linked to the concept of self-efficacy, i.e., a person's subjective conviction that he or she can successfully perform the desired behavior (Bandura, 1982). The importance of self-efficacy for effort and persistence in activities is so central that the construct is explicitly considered in several other theories: as a moderator in goal-setting theory (Locke and Latham, 2002, 2013), as one of four factors in the ARCS model (Keller, 1987), as a mechanism in social cognitive theory (Bandura, 2001a,b), as a determinant in the theory of planned behavior (Ajzen, 2002) and the technology acceptance model (Davis et al., 1989) and as a factor for decisional balance in the transtheoretical model of behavior change (Prochaska & Velicer, 1997). Hence, the provision of self-efficacy information through performance accomplishments, vicarious experience, and verbal persuasion (Bandura, 1978) is essential for motivation, learning and behavior change. Concerning *performance accomplishments*, all these theories state that immediate feedback on progress toward set goals is a sine qua non for perceptions of competence and self-efficacy Furthermore, immediate feedback supports flow experiences

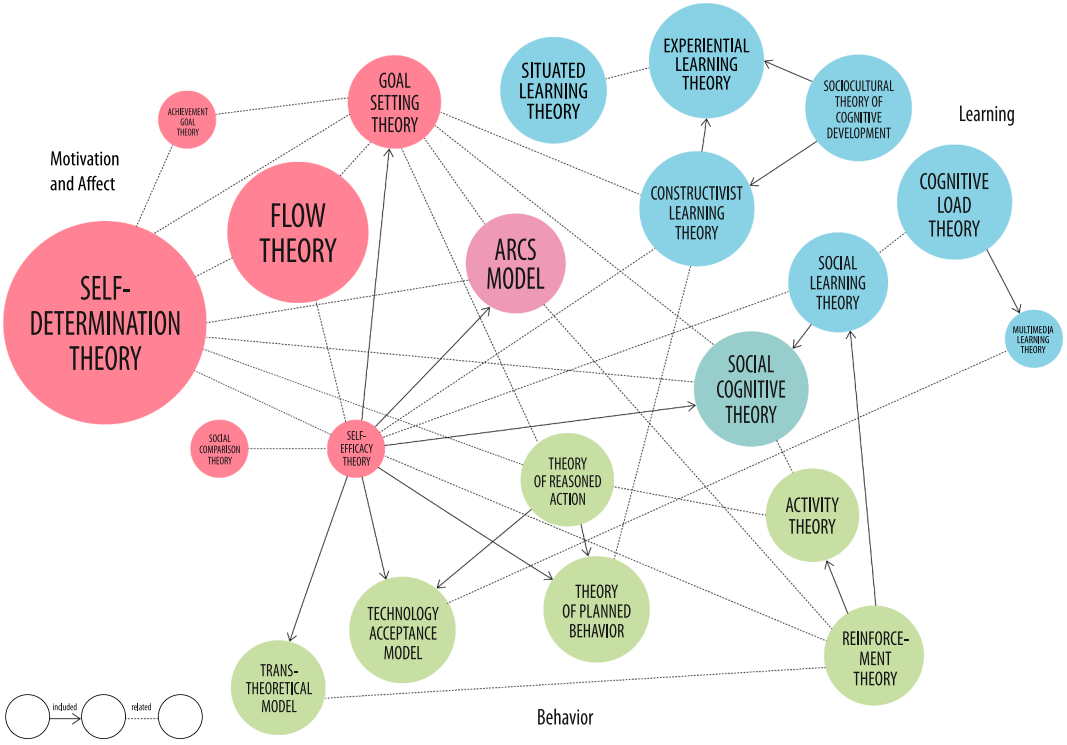

Fig. 2. Theoretical landscape: Relationships of theoretical foundations in research on gamification, serious games and game-based learning.

(Csikszentmihalyi, 2014; Csikszentmihalyi & Csikszentmihalyi, 1988). Studies indicate that one of the most widely used game elements (Koivisto & Hamari, 2019), points, as well as levels and progress bars, can provide users with immediate information about their actions and progress within the system, thereby presenting immediate feedback and visible progression (Dicheva et al., 2015; Ding et al., 2020). Feedback in serious games and game-based learning can also take the form of responses from dialogues with non-player characters or instant feedback messages related to game controls and challenges performed (Laine & Lindberg, 2020). Consequently, we derive the following principle of how gamification works:

P3: Immediate feedback. *Gamification can provide users with direct feedback on their actions.*

The ARCS model of motivation is an instructional design model. It is primarily a theory of motivation based on expectations and values, the latter being a person's preference for certain outcomes driven, for example, by the three basic psychological needs of self-determination theory (Keller, 1979). However, it can also be considered part as a learning theory because it focuses on motivation in an educational context. Instructional strategies for each of its factors – attention, relevance, confidence and satisfaction – include positive reinforcements, which are also emphasized by reinforcement theory (Skinner, 1953). Reinforcements, besides immediate feedback, also represent a form of performance accomplishments to promote self-efficacy (Bandura, 1978), and continuous reinforcements are critical to maintaining behavior change from a transtheoretical model perspective (Prochaska et al., 1992). Cognitive evaluation theory as a sub-theory of self-determination theory adds that positive external stimuli must be primarily informative and not controlling in nature to achieve the desired effects (Ryan & Deci, 2017). In addition, both activity theory and social learning theory emphasize the central role of behavioral reinforcements but extend the sole significance of stimuli by a cognitive activity system (Vygotsky, 1978) and observational learning processes (Bandura, 1971). While from a self-determination perspective (Ryan & Deci, 2020), punishments or monetary incentives can be counterproductive as reinforcers, game elements such as badges and trophies (Suh et al., 2018), in-game rewards (Berkovsky et al., 2012), praise messages (Carenys & Moya, 2016; Kordaki & Gousiou, 2017) or status symbols, which are commonly used in gamification systems, serious games and game-based learning (Klock et al., 2020; Rapp, 2017a), are more informational in nature about the performance and relevance of the user's progress and thus can represent effective forms of reinforcements. Moreover, gamified environments can also offer effective incentives in the form of additional game features, including unexpected ones (Rapp, 2017b) or virtual gifts and loot (Xu et al., 2020). Therefore, we derive the following principle of how gamification works:

P4: Positive reinforcement. *Gamification can reward users for their performance and communicate the relevance of their achievements.*

On the other hand, the importance of *vicarious experience* (Bandura, 1978), that is, observing the performance of others, is essential not only for motivation but also for social learning processes as outlined in social learning theory (Bandura, 1971). Social cognitive theory, which builds on social learning theory, integrates the role of vicarious learning by observation, self-efficacy, and self-regulation by goal-setting into what is called a self-system (Bandura, 2001a,b). It parallels the activity system postulated in activity theory (Vygotsky, 1978), thus emphasizes the importance of both social comparisons and self-imposed goals for learning. From a different perspective, cognitive load theory states that most knowledge in long-term memory is acquired by observing others, which is expressed in the borrowing and reorganizing principle (Sweller, 2010). Vicarious experience is also central to social comparison theory, which states that people have a natural urge to evaluate their abilities in comparison with others (Festinger, 1954). In this context, the opportunity to make private comparisons and the certainty of not revealing one's inferiority to others are essential for social comparison processes to be motivating (Buunk & Gibbons, 2007). Research has demonstrated that gamification, serious games and game-based learning can represent suitable interventions to facilitate social comparisons, e.g., with elements such as leaderboards (Christy & Fox, 2014) or status symbols and rankings (Ding et al., 2020). Moreover, social comparisons can manifest in duels and contests (Klock et al., 2020) or reputation systems (Rapp, 2017a) and in-game communication (Laine & Lindberg, 2020) that enable interindividual social recognition. Social comparison and competition in gamified systems is perceived as motivating by most users (Bayuk & Altobello, 2019) and intra- and inter-team competitions have been shown to be critical mechanisms for motivation and participation in gamified systems (Morschheuser et al., 2019). Likewise, competitive game elements are pivotal mediators of team effort and performance (Dissanayake et al., 2019). As a result, we derive the following principle of how gamification works:

P5: Social comparisons. *Gamification can allow users to see their peer's performance.*

The theory of reasoned action introduces a new aspect: in addition to the behavioral attitude based on outcome expectations, behavioral intention depends on the subjective norm, i.e., normative beliefs towards peer expectations (Ajzen, 1985). Activity theory strongly supports the importance of community and cultural rules in the activity system (Engeström, 1987, 2001), and the basic psychological need of relatedness from self-determination theory expresses the crucial need for conformity and proximity with peers (Ryan & Deci, 2017). As extensions of the theory of reasoned action, the theory of planned behavior (Ajzen, 1991) and the technology acceptance model (Davis et al., 1989) also incorporate the importance of normative beliefs as determinants of behavioral intention. This suggests that social comparison mechanisms should be reinforced through the exertion of social pressure and support for a common goal. Gamification, serious games, and game-based learning can allow users to form teams, master team challenges, collectively vote on options and connect in social networks (Klock et al., 2020). Dividing users into subgroups or teams and supporting their interdependence through shared gamified tasks may create a sense of belonging and positively foster the process of behavior change (Rapp, 2017a, 2017b). For example, game-based learning systems can require students to participate in group activities in a collaborative space (Carron et al., 2008). In addition, exchange guilds allow people to support each other with appropriate suggestions when facing difficulties (Rapp, 2017b). In this regard, communication in games and gamification that enables social support can be realized synchronously, e.g. through chats, or asynchronously, e.g. through discussion forums (Laine & Lindberg, 2020; Vanduhe et al., 2020). Furthermore, the introduction of social network features with mentoring influencers (Rapp, 2017b) or the conveyance of social norms through the presentation of average statistics (Rai & Beck, 2017) can represent suitable game elements for influencing normative beliefs towards behavior change. From this, we derive the following principle of how gamification works:

P6: Social norming. *Gamification can connect users to* support *each other and work towards a common goal.*

The transtheoretical model of behavior change assumes that behavioral changes occur in four distinct phases (Prochaska et al., 1992). In each phase, different psychological processes take place that must be supported to lead to the subsequent stage. Although not directly related to phases and thus not a direct theoretical link, other theoretical foundations also emphasize interindividual differences. Self-determination theory (Ryan & Deci, 2020), flow theory (Csikszentmihalyi, 1975, 2013) and self-efficacy theory (Bandura, 1982) recognize that people differ in their abilities but share similar needs for competence. Goal-setting theory (Locke & Latham, 2002, 2013) includes ability and personality as critical moderators of the goal-performance relationship. And constructivist learning theory (Jonassen, 1999) which includes both individual constructivism (Piaget, 1977) and the sociocultural theory of cognitive development (Vygotsky, 1978), emphasizes the importance of *scaffolding*, i.e. adjusting and structuring tasks to the learner's abilities to support successful learning. Thus, it is

important to tailor tasks and complexity to the individual's skills, knowledge, and behavioral level. Gamification and serious games have been shown to be appropriate tools to illustrate learning potentials at a current stage (Klock et al., 2020), e.g., through knowledge maps (Borges et al., 2016) and skill trees (Barata et al., 2017). Moreover, challenges in gamification and game-based learning systems can be tailored to the learner's current skill level (Dicheva et al., 2015), e.g., by tying the difficulty of the challenge to levels (Gordon et al., 2013; Simões et al., 2013) or by using machine learning algorithms (Gordon et al., 2013). In this respect, educational games surpass traditional teaching methods (Davis et al., 2018). In terms of behavioral change, fictional avatars can be designed in serious games to go through the different behavioral phases (Bahia et al., 2014), and various gamification elements can be selected to support the different stages of behavioral change (Rapp, 2017a), e.g. statistics and messages for initial information provision in the pre-contemplation stage, followed badges and rewards to reinforce the user's effectiveness in the preparation stage and level-ups or leaderboards in the action and maintenance stage (Alsaleh & Alnanih, 2020; AlSkaif et al., 2018). Thus, we derive the following principle of how gamification works:

P7: Adaptive content. *Gamification can adapt tasks and complexity to the abilities and knowledge of the user.*

According to constructivist learning theory, in addition to adaptive content, *coaching*, i.e., supporting learning through motivational prompts, assistance, and reflection (Jonassen, 1999) plays a central role in successful knowledge construction. Sociocultural constructivism underlines that for learners to progress, it is imperative that they be guided within their *zone of proximal development* (Vygotsky, 1978). Similarly, the theory of planned behavior (Ajzen, 1991) emphasizes the importance of actions that nudge the individual to reach the next stage of behavioral change, which is referred to as *verbal persuasion* in self-efficacy theory (Bandura, 1982). Gamified systems have been shown to be effective tools for nudging (Afshar Jalili, 2019; Kwan et al., 2020). For example, gamification and serious games can provide guidance through elements such as suggestions, tips, messages and highlighting of items or elements (Klock et al., 2020), that help, suggest, or warn to follow a path (or not). In addition, role-playing can be used to guide students through different aspects of a problem (Hwang et al., 2015). Hence, we derive the following principle of how gamification works:

P8: Guided paths. *Gamification can nudge users towards the actions necessary for achieving the goals.*

Experiential learning theory, which builds on constructivist learning theory and the sociocultural theory of cognitive development (Kolb & Kolb, 2013), assumes that knowledge is acquired primarily through personal and environmental experiences rather than instruction (Kolb, 1984). Situated learning theory extends this notion, stating that conceptual knowledge cannot be abstracted from the situations in which it is learned and applied (Brown et al., 1989). Hence, learning environments need to be designed authentically so that students can learn by linking their prior knowledge to real-world scenarios as they participate in learning activities (Hwang et al., 2015). For example, through problem-based learning, case-based learning, and cognitive apprenticeship, learning can be embedded in realistic contexts and supports experimentation with multiple perspectives and ways to solve problems (Dabbagh & Dass, 2013). This is also relevant to support feelings of autonomy, one of the three basic psychological needs of self-determination theory (Ryan & Deci, 2017). Gamification can allow users to discover and choose multiple different paths and options on the way to a goal (Dicheva et al., 2015), e.g. through mechanics such as nonlinear gameplay or branching decisions (Klock et al., 2020). For example, game-based learning systems such as Duolingo provide choices between different paths of learning tasks and tests (Rachels & Rockinson-Szapkiw, 2018). Moreover, serious games can offer fictional environments in which learners can act freely and explore and try different paths and options to achieve the goal (Rapp, 2017a) and learn about specific topics (Wrzesien & Alcañiz Raya, 2010). Augmented reality games allow for similar exploration in real-world environments (Furió et al., 2013). Therefore, we derive the following principle of how gamification works:

P9: Multiple choices. *Gamification can allow users to choose between several different options to achieve a certain goal.*

Finally, the technology acceptance model emphasizes the importance of ease of use in the acceptance of information systems (Davis et al., 1989), so that users perceive self-efficacy (Bandura, 1982) in using the system. Similarly, multimedia learning theory (Mayer, 2005), based on cognitive load theory (Sweller, 1988), suggests the importance of ease of use to minimize *extraneous cognitive processing* that distracts users from actively processing the learning content (Mayer & Johnson, 2010). Game-based learning and serious games can divide complex tasks into shorter and simple sub-tasks (Simões et al., 2013). In addition, educational simulations can support learning by abstracting real-world problems and contexts to their essential characteristics (Ranchhod et al., 2014). Studies have shown that game-based learning can successfully direct cognitive effort towards essential and generative processing when designed with, for example, self-explanation features (Johnson & Mayer, 2010) and explanatory feedback (Mayer & Johnson, 2010). Moreover, onboarding also referred to as tutorials, can provide users with relatively simple tasks to get started familiarize themselves with the system (Iosup & Epema, 2014; Kavaliova et al., 2016). Consequently, we derive the following final principle of how gamification works:

P10: Simplified user experience. *Gamification systems are usually easy to use and can simplify content.*

The discussion of relationships between the theoretical foundations used in research on gamification, serious games and game-based learning thus enables the identification of ten underlying theoretical principles that help explain how gamification can achieve its positive effects, summarized in Table 5. To enhance the overview, we distinguish three categories of principles: those that lead people to the intended results, those that enhance individual relevance, and those that enable social interaction and positive social effects on individual behavior.

6. Implications and further research suggestions

The foregoing review and discussion constitute the first to explicitly focus on the theoretical foundations used in research on gamification, serious games and game-based learning. Moving from an observational perspective to an explanatory perspective, we examined the theoretical foundations used to design and evaluate gamified interventions and explain the effects of gamification, serious games and game-based learning in our systematic meta-review. Subsequently, we highlighted the common underlying principles of the most prevalent theories identified in our review that help explain how gamification, serious games and game-based learning can achieve positive affective and motivational, (cognitive) learning and behavioral effects. Our findings provide valuable guidance for further theoretical research as well as for the practical design and use of gamification in various application contexts.

6.1. Implications for theory

This systematic meta-review has shown that the landscape of theoretical foundations that have so far been used to explain *how* gamification, serious games and game-based learning influence affect and motivation, behavior, and learning in different contexts, has acquired a fascinating variety. In conjunction with the growing interest in gamification research, this is a positive sign: While in earlier stages of gamification research, the focus has been set primarily on *whether* gamification produces positive effects (Nacke & Deterding, 2017), this review demonstrates that scientific interest has successfully broadened and expanded by investigating *how* and *why* this takes place.

Self-determination theory is an omnipresent theoretical framework

Table 5
Theoretical principles that help explain the effects of gamification.

Theoretical principles	Related theoretical foundations
Principles that guide towards the intended behavioral outcomes	
P1: Clear and relevant goals. Gamification can transparently illustrate goals and their relevance.	Goal-setting theory, flow theory, self-determination theory, ARCS model, constructivist learning theory, theory of reasoned action, theory of planned behavior
P3: Immediate feedback. Gamification can provide users with direct feedback on their actions.	Self-determination theory, self-efficacy theory, goal-setting theory, ARCS model, social cognitive theory, theory of planned behavior, technology acceptance model, transtheoretical model of behavior change, flow theory
P4: Positive reinforcement. Gamification can reward users for their performance and communicate the relevance of their achievements.	Reinforcement theory, ARCS model, self-efficacy theory, transtheoretical model of behavior change, self-determination theory, activity theory, social learning theory
P8: Guided paths. Gamification can nudge users towards the actions necessary for achieving the goals.	Constructivist learning theory, sociocultural theory of cognitive development, theory of planned behavior, self-efficacy theory
P10: Simplified user experience. Gamification systems are usually easy to use and can simplify content.	Technology acceptance model, multimedia learning theory, cognitive load theory
Principles that foster individual relevance	
P2: Individual goals. Gamification can allow users to set their own goals.	Self-determination theory, achievement goal theory, goal-setting theory, social cognitive theory
P7: Adaptive content. Gamification can adapt tasks and complexity to the abilities and knowledge of the user.	Transtheoretical model of behavior change, self-determination theory, flow theory, self-efficacy theory, goal-setting theory, constructivist learning theory, sociocultural theory of cognitive development
P9: Multiple choices. Gamification can allow users to choose between several different options to achieve a certain goal.	Experiential learning theory, situated learning theory, self-determination theory
Principles that enable social interaction and positive social effects	
P5: Social comparisons. Gamification can allow users to see their peer's performance.	Self-efficacy theory, social cognitive theory, social learning theory, cognitive load theory, social comparison theory
P6: Social norming. Gamification can connect users to support each other and work towards a common goal.	Theory of reasoned action, activity theory, self-determination theory, theory of planned behavior, technology acceptance model

in gamification research. It is by far the most used theory to this date. It was used in 82 papers, followed in popularity by flow theory, constructivist learning theory, experiential learning theory and cognitive load theory as the most common theories. In contrast, 54 of the 118 theories identified have only been used once so far. This observation may be explainable by the fact that self-determination theory depicts a macro-theory of human motivation, development, and health (Ryan & Deci, 2000a,b), and hence marks a broad framework by definition. Our finding that self-determination theory is also one of the theories most often associated with other theoretical foundations (see Fig. 2 and Table 5) supports this assumption. Similarly, several of the most prevalent theories may generally be applicable in different contexts since psychological constructs such as flow or behavioral determinants from the theory of planned behavior have not been developed to explain motivation and behavior in specific contexts but rather in general terms. Other theoretical foundations, especially those that were used by only one or two papers, are more context-specific (e.g. Sexual Health Model, Robinson, 2015), which may explain their lower popularity.

It remains to be answered why some crucial theories, such as self-efficacy theory, which is a theoretical basis for much more commonly used theories (e.g. the theory of planned behavior, social cognitive theory and the technology acceptance model, as shown in Fig. 2), are not adequately investigated to explain the effects of gamification, serious games and game-based learning. Likewise, expectancy-value theory (Lawler & Porter, 1967) has only been mentioned in one of the reviews, while it provides essential insights for explaining motivational differences based on presumptions about behavioral consequences and forms the basis for the much more popular ARCS model (Keller, 1979). Why are certain theories preferred in this case? Further theoretical research should explore the possibility of making greater use of the theories that form the basis for others, in order to examine whether the observable choice of theoretical foundations is due to the actual added value of the most popular theories, or rather a result of the application context (e.g., the ARCS model for instructional design might simply be more familiar to educational researchers than the underlying expectation-value theory).

In addition, we suspect important connections and interrelations between the theories (indicated as dashed lines in Fig. 2), which are based on the main assumptions of the respective theories. Since the principles that help to explain how gamification works were derived from these relationships, further studies are invited to investigate and validate these theoretically established links.

The great variety of 118 different theoretical foundations in use also shows that there is no single theory that can explain how gamification works. Moreover, it reflects that gamification is an important and developing (research) topic in various contexts. The theoretical bases in gamification, serious games and game-based learning research address different outcomes regarding motivation and affect, behavior, and learning, and reflect attempts to explain the effects of gamification from different angles. As Keller has pointed out in the context of motivation, volition and performance, one of the future goals of gamification research should be to consider a broader variety of theoretical foundations to demonstrate empirically how gamification works, rather than choosing only one of these theories (Keller, 2008). For example, it is useful to find out how gamification motivates, but it becomes even more effective if these insights are directly linked to how gamification also transforms motivation and intention into behavior and learning outcomes. Since many theoretical foundations are at least partially interlinked, gamification research could benefit from such synergies. In this work, we tried to derive basic principles from the core assumption of several theories that help explain the effects of gamification. In future empirical research, these theoretically deducted principles should be tested, challenged, and refined, so that the "how" and "why" of gamification can be explained even more concretely and precisely.

6.2. *Implications for practice*

The present systematic review demonstrates that gamification, serious games and game-based learning provide a high potential for improving affect and motivation, behavior and learning outcomes in various important areas such as education, health, work, or sustainability. When there is a lack of motivation or performance or if learning behavior and outcomes display room for improvement, gamification can represent a suitable solution when it is a successful manifestation of several principles deemed important by theories on motivation and affect, behavior, and learning. Especially in contexts where motivation usually fades over time, such as education (Wigfield & Wentzel, 2007), gamification, serious games and game-based learning might be useful tools to engage learners in continuous learning, especially since it has been shown that teachers often lack preparation on how to motivate their students (Schürmann et al., 2020). Including theory on gamification, serious games and game-based learning and their impact into teacher education therefore is another crucial practical implication of this research. The same counts for practitioners in other fields: While research has already addressed the previously criticized lack of theoretical foundations in research interventions on gamification and serious

games, practice should now be invited to follow up with gamification design built on these theoretical findings. This applies to all contexts in which gamification has been used in the past and will be used in the future, including, for example, health, the workplace or education.

Those who want to benefit from gamification, serious games and game-based learning, such as teachers, managers or physicians, need to develop competencies regarding the underlying theoretical foundations and their principal commonalities. For example, teachers who want to adopt gamification to motivate and engage their students and improve learning outcomes should understand the importance of (P1) clear and relevant goals as well as (P8) guided paths to connect game elements, make sure that the students get (P3) immediate feedback and are thereby (P4) positively reinforced, that the (P10) user experience is simple and supports the work on (P2) individual goals, while the system provides (P7) adaptive content and (P9) choices on the side of the students. A possibility for (P5) social comparison and (P6) social norming should also be given to achieve the best results. In light of these recommendations, it is important to note that the appropriate choice of principles still depends on the context and goals of gamification, and not every principle is necessarily appropriate in every case. For example, an intervention aimed at driving the efforts of student teams to collaboratively discover solutions to gamified problems might intentionally omit social comparisons to avoid competitive dynamics. This highlights that practitioners need to develop *gamification literacy* in the sense of an ability to engage with gamification-related issues and ideas of gamification within their application context. Teachers, managers, doctors, and all those who want to benefit from gamification need to learn how to implement it concerning their specific goals. This is particularly relevant in the educational and work context now as digital education and remote working become more widespread, for instance, due to the Covid-19 pandemic.

Conclusively, it is apparent that practitioners need to understand the underlying theories and especially the derived basic principles and how they relate to motivation and affect, behavior, and learning, so that gamification practice can benefit from a solid theoretical basis and interventions can be designed adequately and successfully to achieve the desired results.

7. Conclusion and limitations

This systematic review has shown that scientific work on gamification, serious games and game-based learning has used a variety of theoretical foundations from different perspectives to design and evaluate gamified interventions and explain the psychological mechanisms by which gamification achieves its positive outcomes, including theories on motivation and affect, behavior and learning. Most of the theories identified in the course of this review comprise explicitly formulated or conceptual connections, which we illustrated in a graphical representation of the theoretical foundations of gamification research (Fig. 2). From their interrelationships, we derived basic theoretical principles that help explain how gamification works: Through game elements such as points, levels, badges, quests, and many more, gamification can transparently *illustrate goals* and their relevance, lead users through *guided paths* to goal-oriented activities, give users *immediate feedback* and *reinforce good performance* positively, and *simplify content* to manageable tasks. The gamification mechanics can allow users to *pursue individual goals* and *choose between several different progress paths*, while the gamified systems can *adapt tasks and complexity* to the user's abilities. Social gamification elements may enable *social comparison* and *connect users* to support each other and work towards a common goal.

However, this study is not without limitations. First, we chose an umbrella review of the scholarly literature as an appropriate methodological choice to aggregate the divergent findings of the multitude of existing reviews on theoretical foundations of gamification, serious games, and game-based learning. By opting for this methodology, we may have missed empirical or conceptual studies that develop a novel theory based on other theoretical foundations, or non-peer-reviewed research contributions to theoretical foundations, e.g., in book chapters, and therefore cannot claim that our review is fully exhaustive. Second, we based our evaluation of the popularity of various theoretical foundations both on the number of reviews in which any given theory is mentioned and on the scope of the primary research studies in which it was applied. However, five of the 32 reviews that we meta-analyzed did not provide the sum of primary studies that used a particular theory, so the total number of studies listed in our review may be biased. However, the theories mentioned in the respective reviews fit the general distribution of theories in research, so it is likely that the divergent sum of the studies does not affect our results.

Third, we have studied the conceptual links between different theoretical foundations in detail. However, we would like to emphasize that neither our theoretical landscape nor the conceptually derived principles claim to be complete and are open for further development by other scientists. We have, for example, only compared the 21 most popular theories to derive our theoretical principles that help explain how gamification works. There are at least 95 more theories used in primary studies that future research could investigate and link to the effects of gamification, serious games and game-based learning in general or other theories and different contexts in particular. The resulting implications and core assumptions for gamification, serious games and game-based learning are still to be investigated. Also, our derived principles are based primarily on a conceptual discussion, and further empirical research is needed to support their validity and investigate how well the different principles can explain the effects of gamification, serious games and game-based learning.

Finally, it should be noted that our theoretically derived principles that help explain how gamification works share parallels with several design guidelines for successful gamification (Krath & von Korflesch, 2021) that have either been derived from qualitative research (e.g. Israel et al., 2013; Morschheuser et al., 2018; Sezgin & Yüzer, 2020) or have been developed conceptually using specific theories (Liu et al., 2017; Plass et al., 2015). It would support both the validity of our theoretical findings and the validity of the design principles if the basic assumptions on the principles of gamification that lead to its positive outcome matched the guidelines for successful gamification design, and we invite further research for such a profound comparison. In this way, research can gradually gain an accepted understanding of how gamification works and how it must be realized to be successful, thereby reducing or explaining potentially ambiguous results about outcomes and advancing the effective application of gamification and serious games in various application contexts.

Declaration of competing interest

None.