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When Failure Is an Option: A Scoping Review of Failure States in Game-Based Learning

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ORIGINAL PAPER

When Failure Is an Option: a Scoping Review of Failure States in Game-Based Learning

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Abstract
As interest in the use of games and gaming elements within learning environments grows, educators and designers may find it easier to account for winning than for losing and failure. This scoping review examines the role of failure and loss within game-based instructional interventions. Because of the varied methods and relatively small number of articles directly addressing the intersection between failure and loss within game-based instructional interventions, a scoping review was undertaken. This review included 14 peer-reviewed articles which explored a range of instructional contexts implementing failure state game mechanics. We identify several key takeaways that indicate how failure state mechanics may have considerable promise in meeting specific instructional goals during game-based instructional interventions. Perhaps most notable in the findings is the delicate relationship between perceived risk of failure relative to instructional utility. We define this relationship with a new term, *unit of failure*, which aims to assist practitioners in operationalizing failure and loss in game-based instructional interventions.

Keywords Educational gaming · Failure · Game-based learning · Game mechanics · Productive negativity · Risk · Scoping review

Introduction

Game-based learning, gamification, and serious games have been a topic of considerable interest within the educational space (Clark et al., 2016; Ellaway, 2016; Larson, 2020). Game-Based Learning (GBL) has been described as an experience where gameplay and instructional content have both defined and conjoined learning outcomes. GBL experiences are designed to balance subject matter with gameplay and often involve problem solving, level progression, and challenges (Qian & Clark, 2016). Serious Games are considered games designed for a purpose beyond entertainment; generally this purpose involves facilitated educational contexts (Larson, 2020). Lastly, Gamification has been defined as a way to use individual game elements within non-game-specific contexts; where practitioners strive to take the best parts of video games, such as awards and badges, and apply them to an instructional experience (Subhash & Cudney, 2018).

There exists considerable overlap between these three concepts and their application. For the purposes of this study, we have posited that each of the classifications may include some forms of game-based instructional intervention which could fall under multiple classifications. In this study, the three classifications are represented by the catch-all term, *game-based instructional intervention*. Research findings have routinely indicated game-based instructional interventions, regardless of classification, have a positive effect on participant motivation and engagement, and have seen implementations from practitioner and academic perspectives across nearly the full spectrum of educational contexts including K-12 (Ifenthaler et al., 2012; Reese, 2003), higher education (Qian & Clark, 2016), vocational (Mora et al., 2017), and the medical field (Erhel & Jamet, 2013; Wu et al., 2012).

Instructional Experience and Game Mechanics

There has been interest in exploring ways to tie games more into the instructional experience.. Of note is an originating call to action by Clark et al. (2016) to look beyond games as simply a medium for content delivery, but as a multifaceted

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tool which can enhance educational experiences and improve learning outcomes by leveraging the very structural elements that make games effective in general. Since 2016, there have been several studies that have aimed to answer this call. Alexiou and Schippers (2018) provided a conceptual framework outlining three tenets of digital game user experiences which affect engagement, motivation, and learning outcomes: a clear narrative, aesthetics, and game mechanics. Power et al. (2020) went further, looking at the role game-based difficulty level plays in learner motivation and self-efficacy. Both studies suggest a need for additional research within the space of game mechanics toward enhancing game-based instructional interventions.

Werbach and Hunter (2012) define game mechanics as the basic processes that drive action forward and generate player engagement. Gee (2013) identified mechanics as the things players are experiencing, doing, or reacting to during the game. The study of effective mechanics within game-based learning experiences has been established as a topic of significant interest throughout the fields of education and instructional design. One game mechanic that exists in nearly every game, and has not been extensively researched, is the role of loss or failure within specific game-based learning interventions (Jensen et al., 2016). To address this gap, we focus our scoping review on how failure and loss are represented in game-based instructional interventions as a game mechanic.

Failure and Loss

Failure and loss are common traits in nearly any game (Anderson et al., 2018a; Juul, 2013). We suggest that the ability for a participant to win or lose is the very thing that makes a game a game. Games within educational settings are no exception. Within games, failure is routinely used as a tool to provide feedback on how to accomplish tasks necessary for completion. The consequences for failure are often depicted in a player's loss of cards, coins, or even their characters' lives. Failure within game-based learning experiences is designed into the overall instructional intervention, openly expected, and considered a necessary step in the learning process (Plass et al., 2016). This presents a unique challenge to educators and designers interested in implementing game-based instructional interventions, as failure is often discouraged or explicitly avoided within educational settings (Manalo & Kapur, 2018). For instance, as opposed to the consequences associated with a poor grade on an exam (Anderson et al., 2018b), the consequences of failure in game-based learning interventions often encourage risk taking, exploration, and creativity (Hoffman & Nadelson, 2010). Therefore, game-based educational experiences may be particularly useful in assisting learners in failing up (Anderson et al., 2018a) or through productive failure (Kapur, 2009; Kapur & Bielaczyc, 2012), representing a natural convergence between the use of productive failure and game-based instructional interventions to create both engaging and deeply meaningful learning experiences.

Problem Statement

The challenge is then for researchers and practitioners to understand the best use of failure and loss within game-based instructional interventions. How much failure can a learner handle within a game-based instructional experience? In what instructional contexts do the use of failure mechanics make the most sense? How do instructional designers implement instructional interventions to leverage the mechanic of failure that is ubiquitous in nearly all forms of games?

This review represents the first attempt to scope all available existing research with the focus of uncovering the specific use of failure and loss states within game-based instructional interventions. The purpose of this study is to examine the way that failure or loss as a game mechanic has been studied within educational gaming contexts. We are particularly interested in identifying the scope and severity of failure and loss states within these settings, and ultimately identifying the benefits and drawbacks to their use.

Methods

Research on game-based instructional interventions includes studies utilizing a vast array of methods and experimental variables. Despite this breadth of studies, Jensen et al. (2016) identifies a lack of extensive exploration focusing on the use of failure or loss within game-based learning experiences. To address this gap, we conducted a scoping review to determine the scope of the existing literature.

One might ask: why not perform a meta-analysis or a systematic review? A meta-analysis is most appropriate when there exist a number of studies which answer similar research questions, share common methodologies and analyze similar, if not the same, dependent variables (Schutt, 2018). The articles in our scoping review do not meet these criteria. As for whether this study should be considered a systematic review, one of the defining characteristics of a systematic review is a clear research question from which to start (Wright et al., 2007). In a scoping review, the starting point is an exploration of the extant research which informs the development of research questions. In this initial phase the researchers are developing their research questions by identifying the extent, range, and nature (scope) of research activity within a specific topic and a subsequent mapping of key results (Snelson & Hsu, 2020). This differs from the starting point for a systematic review, where the researchers would begin first with the research question and use that to identify relevant research (Arksey & O'Malley, 2005; Dennen et al., 2020).

In comparison to a meta-analysis or a systematic review, our study exemplifies why a scoping review is helpful when investigating elements within the literature that have yet to see extensive research focus, utilize consistent methodologies, or leverage established conceptual frameworks, as is the case with failure and loss within game-based instructional interventions. As with several examples of scoping reviews (Levac et al., 2010; Pham et al., 2014; Snelson & Hsu, 2020), we have implemented the six-step scoping review framework recommended by Arksey and O'Malley (2005). These suggested steps begin with 1) reviewing literature to define appropriate research questions to guide the review, 2) querying databases to find articles, 3) reviewing and narrowing these articles to a final list, 4) analyzing the articles, 5) synthesizing and reporting out of results, and 6) a final optional step of consultations. We utilized the first five steps and present them in the following sections.

Stage One: Reviewing Literature

We began by reviewing literature focused on game-based learning as well as an emergent awareness of the use of productive failure (Manalo & Kapur, 2018) in educational contexts. We conducted a preliminary scan of literature that appeared to address the intersection of these topics; placing special focus on contexts, general themes, and nuanced definitions. From this scan, we drafted the following research questions for the scoping review:

1. What is the extent and range of the current research regarding the handling of failure and loss states in game-based interventions within educational settings?
2. What is the scope and severity of failure within these settings (i.e., loss of points, character death, etc.)?

The research questions aimed to strike a balance between the broad focus of a somewhat undefined topic and the precision of a systematic inquiry. To aid in the validity of the scoping review, we followed similar procedures to other scoping reviews in educational contexts (Arksey & O'Malley, 2005; Dennen et al., 2020; Levac et al., 2010; Pham et al., 2014; Snelson & Hsu, 2020).

Stage Two and Three: Article Selection

After developing our research questions, we next moved to article selection. We implemented the PRISMA guidelines for article selection and identification stages (Liberati et al., 2009; Tricco et al., 2018). We queried academic databases including Web of Science Core Collection: Science Citation Index Expanded, Social Sciences Citation Index, Arts & Humanities Citation Index and Emerging Sources Citation Index; Academic Search Premier; Education Research Complete; ERIC (Education Resource Information Center); and Proquest Educational Journals. The querying of these databases occurred in September 2020. To ensure that we had identified all relevant articles, each database was queried three times, each time with one of the broad search phrases of "game-based learning," "gamification," or "serious games." This deliberate triplication was performed to account for the scope and meaning of these specific terms being at times interchangeable within the knowledge base and to avoid limiting the query by defining game-based instructional interventions in one way. In each query instance the results were then further refined to the search terms "fail*" or "los*," in doing so including articles that specifically mention in the title or abstract failing, failure, fail, loss, losing, or other potential words that could be included with the use of a wildcard symbol "*" in search queries. Each query was then filtered to include studies which were published between 2010 and 2020, were published in a peer-reviewed journal, and were available in full-text English.

The date range was selected based on a citation report generated from Clarivate's Web of Science, which gives evidence to the rise of considerable interest (in the form of citations) in this article's three game-based instructional intervention subject areas occurring around the year 2010 (Fig. 1). The citation report indicates articles featuring the topic "Game-Based Learning" exceeded more than 100 citations in the year 2010; "Serious Games" reached this milestone in 2011; and "Gamification" did so in 2014. Comparing these numbers to 2020, the topic "Gamification" saw over 8000 citations for the year, with "Serious Games" and "Game-Based Learning" each garnering 5000 and 4000 respectively, representing the nearly exponential growth of interest within the topic.

Article Filtering

Our initial query identified 985 articles. After removing duplicate entries, we began screening the remaining 600 articles. We reviewed titles and abstracts and excluded articles based on content and words. Exclusion criteria included articles which focused on the play of physical sports and/or leagues, game theory within the context of computer engineering, wildlife (game), gambling, online retail marketing, weight loss, hearing loss, vision loss, and heart failure. The article remained in the pool if it referred to productive failure, use of failure, the role of failure or loss, level progression, in-game challenges, and game difficulty within educational contexts. After this filtering, 51 articles remained. Next, each article was read in full. The articles that met the inclusion criteria set forth by the research questions were selected to be part of this study, and our selection flowchart appears in Fig. 2.

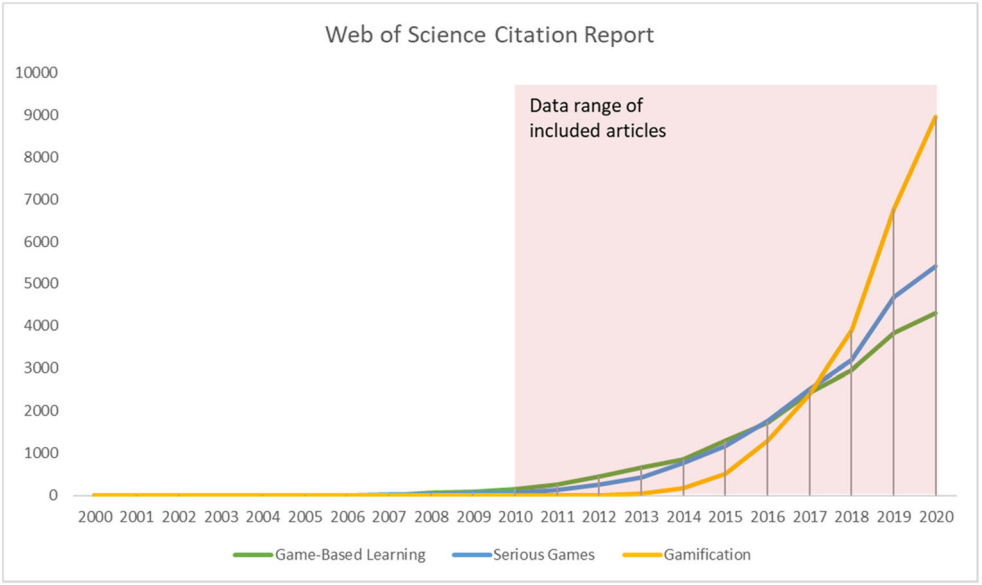

Fig. 1 Graph of Web of Science Citation Report

Stage Four: Identification of Themes

We applied a structural coding method while reading the articles. This initial coding identified content area, purpose, study design, participants, and key findings for each article. Next, descriptive coding was applied to generate an index of subtopics relative to the research questions. This coding included game intervention variant (game-based learning, serious games, or gamification), scope and severity of failure mentioned within the study, *unit of failure*, and whether the study identified any benefits or drawbacks to the use of failure state game mechanics in educational contexts. Additional columns were then added to organize the thematic information extracted from the coded articles to identify meaningful connections between studies.

Stage Five: Summarize and Report Findings

The themes identified during the charting stage were collated and summarized in accordance with recommendations from scoping review methods literature (Arksey & O'Malley, 2005; Levac et al., 2010; Snelson & Hsu, 2020). The following sections extrapolate on these themes to offer key information from across the sample of research studies. These findings are aggregated and organized by research question below.

Findings and Discussion

Overview of Current Research

The research literature on failure and loss states within game-based learning interventions is currently limited and highly variable in depth, thus resulting in only 14 articles meeting the inclusion criteria for this review. Our primary challenge was that our goal was to identify whether failure as a game mechanic was used within a game-based learning study, not whether game-based learning itself is effective. Nearly all articles excluded during the full text review focused on the effectiveness of game-based intervention but did not specifically mention the role of failure or challenge.

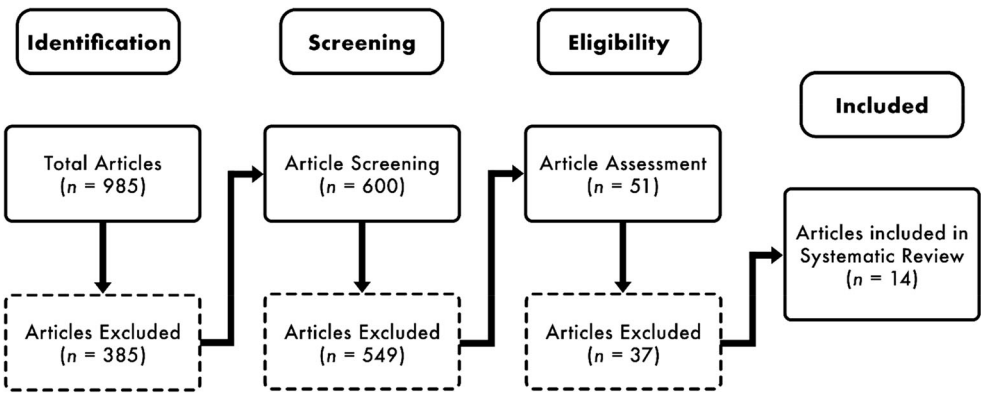

Fig. 2 PRISMA Flowchart of Article Selection

Research Designs

We found that 11 of the 14 articles in our review utilized experimental or quasi-experimental study design. This study design has a pre-test or questionnaire, a controlled game-based intervention, and a post-test questionnaire or assessment. The studies that did not utilize this type of approach focused instead on developing a conceptual framework (Whitton, 2012), in-game data analytics capture (Flores & Rodrigo, 2020), and a qualitative sample study (Glover & Bodzin, 2020). Fig. 3 provides a graphical summary of the focus on game type intervention (i.e., game-based learning, gamification, or serious game) and shows that game-based learning was the most common game-type intervention in the reviewed articles.

We found that the articles covered a variety of academic subject areas (Table 1).

Scope and Severity of Failure within these Settings (I.E. Loss of Points, Character Death, Etc.)?

When turning our focus to the scope and severity of specific failure mechanics within the included studies, three contextual elements surfaced as important concepts. Failure as a mechanic, *unit of failure*, and risk and consequences were identified during the full-text reading and thematic summarization outlined in step five of the scoping review.

Failure as a Mechanic

Several studies focused on the considerable differences in the comprehension and application of failure mechanics in educational experiences. The use of the word "mechanic" here is deliberate. Mechanics represent the basic processes that drive the action forward and generate player engagement (Gopinath Bharathi et al., 2016). As games are oft touted as a means to motivate and engage in learning environments, the use of failure mechanics within game-based learning contexts may appear paradoxical, since failure within learning settings is generally considered undesirable (Manalo & Kapur, 2018). Yet in several studies it appears that the implementation of a deliberate failure mechanic improved engagement, aided in meeting specific learning objectives (Bouchillon & Stewart, 2020; Gauthier & Jenkinson, 2017, 2018), and in one study even led to better recall after the training event (Devonshire et al., 2014).

Unit of Failure

A definition of failure within game-based learning contexts will likely continue to be elusive, as failure may represent both temporary challenges within a specific game action as well as the result of a series of challenges which make up a period of game play (i.e., a level of a game). Thus, failure mechanics potentially represent both small and large functions of gameplay. To organize these functions within the review, a new descriptive term was developed to aid in comprehension: *unit of failure*. *Unit of failure* can be defined as the specific game element which represents failure within the game context. Within the review we found that this *unit of failure* was represented in games as degradation of character health, course grade, patient health, points, time, and tokens (Table 2).

Findings Regarding Unit of Failure

Nearly all the articles (13 of 14) had some means of framing their failure mechanic at the small function level. This game mechanic was typically represented as either points or score. In each of these circumstances a learner's score was known throughout the game-based intervention, and it was clear to the learners that higher scores or points were the desired state

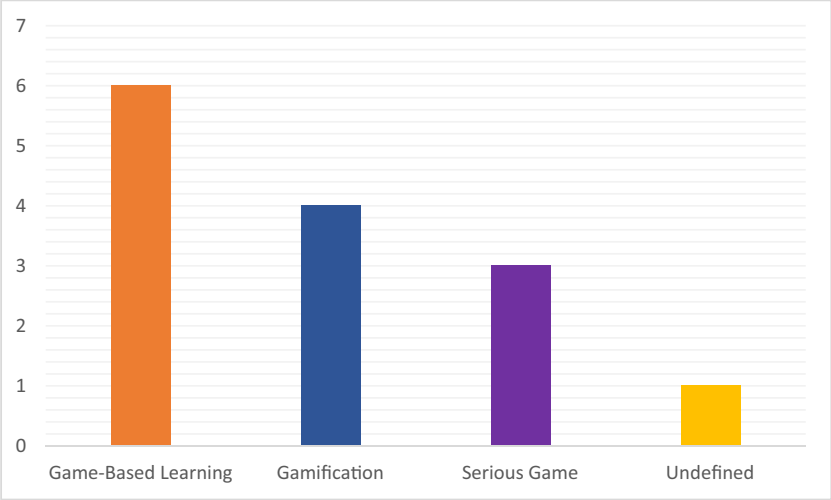

Fig. 3 Number of articles by game type intervention

Table 1 Articles by Subject Area and Participants

Subject Area	Participants	Articles
Animal Sciences	University Students	(Cameron & Bizo, 2019)
Biology	University Students	Gauthier & Jenkinson, 2017, 2018)
Language Skills	Elementary School Students, High School Students	(Chen et al., 2012; Chen & Chen, 2013; Yang et al., 2020)
Dentistry	University Students	(Sipiyaruk et al., 2017)
Engineering	Vocational Students	(Pozzi et al., 2015)
K-12 Science (5th Grade)	Elementary School Students	(Devonshire et al., 2014)
Marketing	University Students	(Robson, 2019)
Medical Education	High School Students	(Glover & Bodzin, 2020)
Programing (C++)	University Students	(Flores & Rodrigo, 2020)
Sociology	University Students	(Bouchillon & Stewart, 2020)

to either win (Cameron & Bizo, 2019; Devonshire et al., 2014) or to progress within the game. In one intervention an abstracted version of points was used. To refine the use of points, Devonshire et al. (2014) introduced the loss of tokens. Two articles (Glover & Bodzin, 2020; Pozzi et al., 2015) used real-world units of failure, as opposed to points or tokens, to ground the learner in the ultimate stakes of the task. Pozzi et al. (2015) utilized a failure state of adding time on a production line which led to production delays. Glover and Bodzin (2020) studied a game intervention for students entering into pre-medical undergraduate studies, using patients' health as the failure state, with continued failure leading to the patient's loss of life. Bouchillon and Stewart (2020) explored the use of a role-playing game mechanic for building immigrant trust which utilized the actual grades on assignments as the *unit of failure*. This meant that if an in-game assignment did not meet the predetermined success metric or rubric, the resultant failure affected the learner's real-life academic standing. Another method of failure was degradation of character health. Two articles (Chen et al., 2012; Chen & Chen, 2013) used this *unit of failure* as represented by an avatar pet's life energy (a digital numerical representation accompanied by visual depictions of degraded avatar health).

Several studies linked these small units of failure to a greater *unit of failure*. Two researchers who measured score throughout the direct game play would then also provide a star value at the end of each level. The lack of stars at the end of each level was an explicitly placed failure mechanic to encourage learners to return and perfect their game play to achieve full stars (Gauthier & Jenkinson, 2017, 2018). While not as explicitly described, it would appear a similar mechanic was also used in other studies (Bouchillon & Stewart, 2020; Glover & Bodzin, 2020; Pozzi et al., 2015). For example, Bouchillon and Stewart used individual grades throughout the semester which led to a terminal grade at the end of the semester. The major differentiator, however, was the lack of opportunity for replay and the potential to achieve in-game perfection.

Risk and Consequences

Perhaps the most notable variances found amidst the studies were the risks and consequences associated with failure. Devonshire et al. (2014) describes risk as a learner's, or user's, participation in an activity or behavior which involves negative consequences or potential loss and failure balanced in

Table 2 Articles by Units of Failure

Unit of Failure	Articles
Degradation of Character Health (Non-Human Avatar)	(Chen et al., 2012; Chen & Chen, 2013)
Course Grade	(Bouchillon & Stewart, 2020)
Patient Health	(Glover & Bodzin, 2020)
Points or Score	(Cameron & Bizo, 2019; Devonshire et al., 2014; Flores & Rodrigo, 2020; Gauthier & Jenkinson, 2017, 2018; Robson, 2019; Sipiyaruk et al., 2017; Yang et al., 2020)
Time	(Pozzi et al., 2015)
Tokens	(Devonshire et al., 2014)

some way with perceived potential positive results. This definition is useful for our purposes in that it explicitly states that activities which involve risk must be participatory and have a balance of negative and positive outcomes. The definition also highlights that risk is perceived, meaning it will vary based on individual learner characteristics and pre-existing schema. This type of insight was critical to understanding the current literature, as well as its greater implications to the broader discussion surrounding the use of productive failure (Kapur, 2009) in educational settings.

Building on this understanding, it became evident why game-based instructional interventions are an ideal setting for the productive use of failure in educational contexts as called upon by Manalo and Kapur (2018). Games inherently require participation (Gee, 2013), thus they cannot be passive in nature. Games may have varying levels of interactivity, especially in the case of games involving group play, but in its most basic form a game is a series of activities which has goals, is interactive, and provides feedback (Clark et al., 2016). Clark et al. (2016) expand that the specific mechanics which make up the goals, interaction, and feedback are what make a game-based learning experience meaningful. Thus, the varying use of risk and consequence in these articles strikes at the core of the challenge put forth both by Manalo and Kapur (2018) and Clark et al. (2016). The proper use of a failure state within a game-based learning intervention may shed light on ways to further implement failure states in non-game-based learning experiences. Within the articles studied in this scoping review, risk and consequence appear to exist on a spectrum where "no risk" exists on one end and "real-life risk" exists on the other. Figure 4 highlights the cardinal elements of the failure state spectrum.

Failure without Risk

Flores and Rodrigo's (2020) study sought to develop a model to identify when wheel-spinning occurs, which is defined as failure as a result of lack of previous knowledge in computer programming contexts. The researchers put forth a no-risk game intervention in which learners could repeat an activity as many times as they liked until they achieved a perfect score. The results were highly variable and indicated that high submissions might represent individuals recognizing that there was no risk in failing activities until they guessed the correct answer. This type of student behavior was echoed in the work of Sipiyaruk et al. (2017). In this study, a serious game was implemented into an undergraduate dentistry course involving an iterative approach where students would suggest potential health promotion interventions. Mirroring Flores and Rodrigo (2020)'s findings, when there was no limitation to the number of submissions, some students appeared to randomly submit their answers.

The Presence of Avatars and Learners' Perception of Failure

The use of avatars and anonymity appears to have a mitigating effect on risk and consequence, especially within social contexts. In both of Chen's studies (Chen et al., 2012; Chen & Chen, 2013) the researchers used game-based avatar surrogates to depersonalize the feeling of failure in the learning experience. The goal being to find ways to leverage the perceived benefits of failure within learning contexts without the associated social stigma of failing amongst peers. Chen and Chen (2013) integrated the use of avatars to facilitate competition via a leaderboard between students. Chen et al. (2012) investigated how abstract the avatar would have to be to mitigate the personal elements of failure. In both studies, failure is considered to have risk within the real-world social context, but since it is represented via an avatar it is contextualized within the game experience. Cameron and Bizo (2019) investigated the implementation of KAHOOT! in a university setting and found that the use of anonymity aided learners in willingness to fail when approaching queried topics. Thus an individual would know their status, but it would be unknown to the general public.

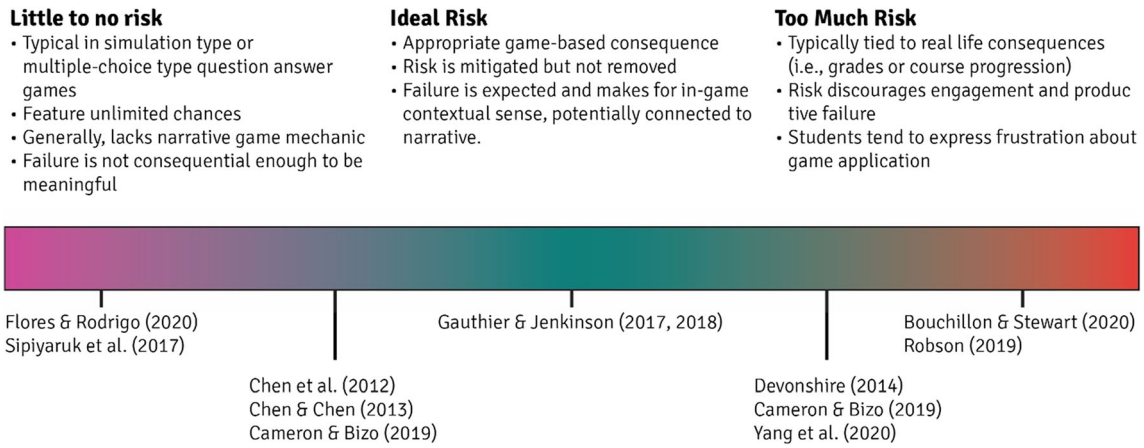

Fig. 4 Failure State Spectrum and related articles

Instances of Positive Failure

These studies have highlighted that failure still seems to carry an associated stigma, with the assumption that it should be avoided if possible and overcome quickly when necessary. But in Gauthier and Jenkinson's two articles (Gauthier & Jenkinson, 2017, 2018), they not only directly program failure into the game-based intervention but highlight some of the calls to action seen in the literature (Clark et al., 2016; Manalo & Kapur, 2018). Gauthier and Jenkinson's two studies utilize two separate interventions in a university setting to assess the importance of game-based mechanics relative to direct simulation. One of these interventions, MolSandbox, is a computer-based simulation experience in which a participant can affect variables and see feedback of their actions in real time. Participants have unlimited attempts to complete tasks based on specific learning goals. The other intervention, MolWorlds, utilizes the exact same simulation as MolSandbox, but does so within the context of a narrative game experience which progresses through levels and scaffolds the participation experience based on predestined pathways. These pathways deliberately place players into situations where the game play leads the learner to a failure state, which is meaningfully relevant to the instructional goal. So whereas in the MolSandbox the participant may act randomly until they figure it out, MolWorld purposely limits or enables particular functionalities to match specific learning objectives. In MolWorld, the narrative experience purposely puts the learner into a situation in which they will fail from time to time. These failure activities inform learners about elements they are missing to be successful in the game and subsequently guide learners into instructionally appropriate actions which lead to success. Throughout the scoping review, no other article seemed to capture the potentiality of the use of failure states within game-based learning experiences as well as this one. It is of interest, too, that the term Gauthier and Jenkinson (2017, 2018) use to describe this mechanic is "productive negativity," which shares striking similarity to Manalo and Kapur's (2018) concept of positive failure.

When Failure Gets Too Real

Progressing to the right on the spectrum (Fig. 4), risk and consequence begin to become more grounded in real life, which research suggests makes the learning experience more meaningful. Devonshire et al. (2014), utilizes a similar gaming approach to Cameron and Bizo (2019), yet with a few notable exceptions. In Cameron and Bizo (2019), the participants play individually in a quiz game. While aware of the overall responses, it is not revealed who submitted each response. In Devonshire et al., the participants play a similar quiz game, but in groups, and the winning group receives tangible real-world prizes. This adjustment in approach continued to mitigate the social stigma of an individual experiencing failure in a learning context by having the groups provide a single answer, yet it emphasized group-to-group competition with the implementation a real-world reward system. Devonshire et al.'s article is of particular note because they conducted their study by providing interventions to different groups with differing levels of risk. Their findings suggest that the presence of varying levels of risk does not affect subject matter knowledge initially, but riskier experiences (i.e., those with more real-world consequences) improved levels of retention in later assessments.

Yang et al. (2020) focused on real-life consequences in examining two types of gaming interventions incorporated into a high school foreign language course. The interventions were used to determine learner progress; if a student could not complete a module they would not be allowed to progress to the following module until the expected standard was met. In this study, progression or lack thereof did not affect course grades but rather the subsequent instructional approach and training materials. Meaning, if a participant failed, they would be provided feedback directly helpful to their success in a subsequent attempt. In a similar vein the two studies that exist at the end of the spectrum (Bouchillon & Stewart, 2020; Robson, 2019) also utilize failure as a means to express course progress. But in these circumstances the *unit of failure* is expressed in the actual course grade, making the game's failure mechanic inherently consequential to the learning experience and thus represented as having the highest risk in practice.

Real-World Contexts and Simulations

There exist two outliers on the spectrum, and while they are included in the mid-range section, they share a unique consideration for application and further research. Both Glover and Bodzin (2020) and Pozzi et al. (2015) immerse the learner in real-world scenarios where the game play is analogous to real life but without real-life consequences. The researchers identify that the game-based implementation, in this case a make-believe assembly line, is a risk-free experience. But in this definition, they are relating the activity to an alternative training approach which would be a hands-on exercise on an actual assembly line with real-world consequences to cost, time, and safety. A similar discussion is had in Glover and Bodzin (2020)'s work within the medical field relating to the importance of awareness within specific medical situations that in real life, as is expressed in the game play, have stakes including the potential loss of life. Both examples highlight some of the benefits within the extensive field of advance simulation applications within training environments but sit somewhat outside the considerations of the generated failure state spectrum.

Limitations

We recognize the use of the scoping review framework may affect the outcomes of our results. We believe this study exemplifies how a scoping review is an ideal framework for finding context, trends, and themes within an existing body of literature which had not yet been systematically investigated for specific subject matter, in this case failure and loss within game-based learning interventions. Notwithstanding, a methodological limitation of this scoping review is in the dataset itself, the selected articles, and the strategy for their selection as described in the methods section. While the authors feel their methods where relatively exhaustive, it is possible that relevant studies were missed outside of the defined procedures. Future research could mitigate this limitation by expanding the querying exercise to include additional databases and/or chosen search terms.

Conclusions

The purpose of this scoping review was to examine the extent and range of research regarding the presence of game mechanics relating to failure or loss in educational settings, to better understand the scope and severity of failure and loss states within these settings, and ultimately identify the benefits and drawbacks in the use of failure and loss game mechanics within educational settings.

Key Findings

Overall, the study revealed insights into how the specific use of failure and loss states within game-based interventions may be beneficial to learner engagement, assessed performance, and retention. In the immortal words of the wise Jedi Master, Yoda, "The greatest teacher, failure is." A primary drawback identified within the study is when failure mechanics are implemented in risk-free instances where learner motivation or accountability are low. The unlimited use of failure, where individuals can fail their way into the correct path through multiple attempts/submissions or even random guessing, were not found to be effective in learning interventions. An additional drawback found in the study is when the *unit of failure* for the game-based intervention is the course grade. There appears to be a negative effect associated with motivation in participating in game-experiences (Bouchillon & Stewart, 2020) when risk levels affect real life.

There are several key findings within this article that are notable for future research or practical application. First, when considering failure mechanics, it is important to consider that activities with potentially negative consequences (i.e., failure) must also be perceived by the participant as having a balance of potential positive consequences. Secondly, individual learners perceive risk and consequence differently based upon individual learner characteristics and pre-existing schema. Next, anonymity and the use of avatars could be considered a mitigating factor in facilitating the use of failure in educational contexts. It could be said that the presence of anonymity in a game-based intervention helps to facilitate positive failure, yet it's unclear if this has a mitigating effect on the effectiveness of the game-based application. And finally in games, failure is considered a central route to learning (Deterding, 2016), failure and productive negativity (Gauthier & Jenkinson, 2018) encourage schema building and are common in gaming environments, and evidence indicates that failure state game mechanics encourage creativity in contextually similar non-game-related scenarios long after the training intervention (Devonshire et al., 2014). This harkens to the broader concept of training transfer (Broad, 1992) where learners apply learned behaviors to new untrained circumstances, a central goal for many educators. These findings directly address the call set forth by Qian and Clark (2016) to look beyond the use of games as a medium to improve engagement and motivation, and consider that specific functions and mechanics of a game (in this case failure states) can generate meaningful learning experiences and support behavior changes beyond the training intervention.

Implications

This study has revealed that the pool of existing literature investigating the use of failure states within educational contexts is small and highly varied in depth. For example, despite including the word "loss" in the initial search queries in the scoping review process, there were no articles included in the full article reading that included loss or the role of losing in their title or abstract. Losing in games could be considered the terminal result of repeated failure, and winning or losing a game is considered a basic tenet of game play, especially within competitive game models. Nearly every study included in this article includes a definition of an explicit win-state, be it a tangible reward (Larson, 2020), peer recognition (Bouchillon & Stewart, 2020), or digital rewards (Gauthier & Jenkinson, 2017, 2018). To the researchers, this reveals that despite the wide breadth of current research within the game-based learning literature, major elements of conventional game design are unstudied and remain an opportunity for the field's future.

Additionally, within the contexts of educational practices and pedagogy found throughout the literature, there does exist conceptual similarity between the concepts of game mechanics as defined within this article and pedagogy. The ways a person moves through a game experience (the mechanics) could be construed as the process in which learning occurs, which is akin to pedagogy in general. Our interests in this study were the specific elements used as failure and loss states

within game-based instructional interventions, as defined by the authors as *unit of failure*. However, a potential limitation to this study is the possibility that literature exists discussing pedagogical considerations in game-based instructional interventions which may include failure and loss without specifically calling out their use. Further study is likely warranted to investigate the connection between specific game mechanics (i.e., failure and loss states) and game-based learning / gamification pedagogy.

Declarations

Conflict of Interest The authors declare that they have no conflict of interest.

Research Involving Human Participants and/or Animals This article does not contain any studies with human participants or animals performed by any of the authors.

Informed Consent Not applicable.

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