Digital Game-based Learning in K-12 Classrooms: Studying Effectiveness and Influential Factors in Instruction

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ABSTRACT

The adoption of new technologies in K-12 classrooms usually generates claims about their effectiveness, but in many cases, these claims are not carefully studied. Furthermore, conclusions drawn from effectiveness studies generally focus on technologies as the sole responsible factor for such effectiveness, without considering other factors and conditions. Through an integrative review, this study evaluated and critiqued the current status of K-12 digital game-based learning (DGBL) to determine the implications and limitations of these effectiveness claims, as well as problems when conducting this type of research. In addition, this study explored factors and conditions, beyond the digital game, that could have had an impact on effectiveness. Findings from this study can provide teachers and researchers a guide to effectively implement and research DGBL in K-12 classrooms, as well as conceptual classifications of factors and conditions that could play an important role when adopting digital games in instruction.

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GENERAL AUDIENCE ABSTRACT

It is common that when new technologies are used in instruction, claims in favor of such technologies are made. However, in many instances, there is not enough or sound evidence to support these effectiveness claims. For this reason, this study has been conducted with the goal of evaluating and critiquing what has been empirically studied so far in K-12 digital game-based learning (DGBL) to determine the extent of these effectiveness claims. In addition, this study has identified research problems and flaws that have been found in empirical studies and how they can be avoided. Furthermore, this study paid close attention to factors and conditions, besides the actual digital game, to determine if they played a role on effectiveness. Finally, a research agenda has been included in this study to fills existing gaps in K-12 DGBL and to guide researchers and teachers when conducting research and adopting digital games in the classroom.

DEDICATION

I dedicate this work to my dear mother, Sandra Alicia. I wouldn't have made it without you!

Dedico este trabajo a mi querida madre, Sandra Alicia. ¡Sin ti, no lo hubiera logrado!

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

Background

The relevance of digital games in the fields of instructional design and education can be connected to the interest of a new generation that is focused on digital communications and learning (Chaudhary, 2008; Hwa, 2018). Even though there is not a unanimous definition of digital game-based learning (DGBL), it can be defined as using a game for learning purposes through a digital platform (Gee, 2007). This trend has also been called game-based learning; however, the distinction is made to focus only on those networked and digital games, and not on any type of game, such as board and analog games. This distinction is necessary since implementing a digital game adds another level of complexity for teachers and it requires a specific set of conditions and resources that is not present in analog games; therefore, when conducting game-based research, DGBL should be addressed separately (Prensky, 2001). Some of these additional conditions and resources that are needed to implement DGBL in a classroom are technology professional development for teachers (Becker, 2007; Schifter, Ketelhut, & Nelson, 2012), technical support (Gros, 2007; Shah & Foster, 2014), and funding (Chang, Evans, Kim, Norton, & Samur, 2015).

Similarly to most instructional interventions such as project-based learning or flipped classrooms, there are several studies that support claims about the effectiveness of K-12 DGBL (Brom, Å isler, & Slavik, 2010; Chen, Liu, & Shou, 2018; Gunter, Kenny, & Vick, 2008; Huang, Huang, & Wu, 2014; Proske, Roscoe, & McNamara, 2014; Tsai, Yu, & Hsiao, 2012). After initial resistance towards DGBL, the trend started to become popular due to the perceived advantages that students experienced such as the possibility to engage in realistic scenarios

(Dickey, 2005; Prensky, 2001) and the opportunity to directly apply what has been learned in a lesson while getting feedback (Cutumisu, Blair, Chin, & Schwartz, 2015; Van Eck, 2006). For these reasons, one of the most relevant issues in the adoption of DGBL in K-12 classrooms is studying and analyzing these claims of effectiveness in instruction. Some of these effectiveness claims in the implementation of DGBL in K-12 settings include higher levels of engagement (Boyle, Connolly, Hainey, & Boyle, 2012; Sabourin & Lester, 2014), increased motivation in the classroom (Augustin, Hockemeyer, Kickmeier-Rust, & Albert, 2011; Eseryel, Law, Ifenthaler, Ge, & Miller, 2014), stronger correlations with persistence (DiCerbo, 2014; Neys, Jansz, & Tan, 2014), and improvement in social skills (Granic, Lobel, & Engels, 2014; Thirunarayanan & Vilchez, 2012). Also, according to some studies, digital games can help teachers facilitate content learning and explain complex concepts and principles (Coller & Scott, 2009; Evans, Nino, Deater-Deckard, & Chang, 2015). However, there are also studies that show no real impact after DGBL implementation took place (Ke, 2008; Ritzhaupt, Higgins, & Allred, 2011).

Historically, the field of instructional design and technology has witnessed how the use of a new technology in education provokes claims of effectiveness (Clark, 1983). Researchers have always attempted to prove how effective a technology can be when used in the classroom and they have used different types of research designs and study to do so (Lockee, Burton, & Cross, 1999). However, in many instances, the research that is conducted to support these claims of effectiveness is not appropriate or sound (Clark, 1983; Lockee et al., 1999; Reeves 1993, 1995).

The extensive amount of empirical data related to DGBL, especially in K-12 settings, has prompted researchers to conduct literature reviews with a variety of goals; however, there are several issues with many of these reviews. Some literature reviews simply summarize current states of the DGBL literature; however, the amount of articles represented in these reviews is not

appropriate to make generalizations or assumptions. Other DGBL literature reviews have focused on the types of participants used in studies, the effectiveness of the DGBL implementation, research designs, learning foci, and the difference in outcomes between experimental and control groups, but without taking into account the quality, reliability, and validity of each empirical study (All, Nunez Castellar, & Van Looy, 2014; Clark, Tanner-Smith, & Killingsworth, 2015; Divjak & Tomic, 2011; Li & Tsai, 2013; Ypsilanti et al., 2014). Other reviews have focused on how DGBL has been assessed, including constructs, assessment instruments and strategies (Bellotti, Kapralos, Lee, Moreno-Ger, & Berta, 2013; Hainey, Connolly, Baxter, Boyle, & Beeby, 2012). However, these studies do not provide specific information on how the study was conducted and the quality of each of the articles selected to conduct the review.

Furthermore, some DGBL literature reviews draw conclusions and state claims about effectiveness, based on media comparison studies (All et al., 2014; Clark et al., 2015), which should be avoided In instructional design and technology (Clark, 1983; Lockee et al., 1999; Reeves, 1993). In addition, some literature reviews have studied and compiled data about existing types of games, features and affordances of digital games, learning theories behind their design, and trends in DGBL (de Freitas, 2018; Jabbar & Felicia, 2015; Tsai & Fan, 2013; Wu, Hsiao, Wu, Lin, & Huang, 2012). However, the information from these reviews is not sufficient or supported by data to make claims about how a digital learning game was effective in instruction. On the other hand, other reviews and studies that focus on effectiveness do not provide explicit and specific information about how the analysis of effectiveness took place (Bellotti, et al., 2013; Chin, Dukes, & Gannon, 2009).

Need for the Study

Many studies attempting to determine effectiveness in K-12 DGBL are not empirical studies and they are presented in the form of white papers, evaluations, and program descriptions (Baek & Whitton, 2013; Whitton, 2009). It is important to determine if there are enough rigorous empirical studies that support K-12 DGBL studies, and not just publications that are not grounded on research.

Moreover, even though several literature reviews have attempted to summarize studies in DGBL, they have not rigorously determined how these studies that claim effectiveness have been conducted and their problems when they were conducted. One of the most relevant problems in instructional design is that studies that claim effectiveness use media comparison studies (Clark, 1983; Lockee et al., 1999). Clark (1983) has stated "that media are mere vehicles that deliver instruction but do not influence student achievement…" (p. 445). Furthermore, he stated that "it is the uncontrolled effects of novelty and instructional method which account for the existing evidence for the effects of various media on learning gains" (Clark, 1983, p. 447).

Based on these claims, it would not be appropriate to link effectiveness or improvements in instruction only to the presence of a digital learning game. As Clark (1983) and Lockee et al. (1999) have stated, in order to claim that media has an effect on learning, such media should have attributes, elements, or characteristics that are unique and not found in other media. These authors have made the case that it is possible to start seeing a relationship between media and learning if these unique attributes are ever found on an instructional technology. In the DGBL literature, there can be found several examples of media comparison studies used to study the effectiveness of DGBL (Hsiao, Chang, Lin, & Hu, 2014; Proske, et al., 2014; Schaaf, 2012). For

this reason, it is necessary to deeply analyze DGBL studies to see if effectiveness is claimed based on media comparison studies.

Besides the issue of media comparison studies, empirical studies in instructional technology have the problem of pseudoscience, as stated by Reeves (1993, 1995). Reeves (1993, 1995) has identified nine characteristics of pseudoscience that are sometimes found in empirical studies: specification error, lack of linkage to robust theory, inadequate literature review, inadequate treatment implementation, measurement flaws, inconsequential outcome measures, inadequate sample sizes, inappropriate statistical analysis, and meaningless discussion of results. In order to determine the effectiveness of DGBL in K-12 classrooms, it is necessary to analyze if empirical evidence supporting these claims have any of the previous characteristics of pseudoscience or any other measurement or research problems. As Reeves (1993, 1995) has stated, when studies are conducted with these measurement problems, the field is engaging in a research agenda that is not socially responsible. Reeves (1993) describes a research agenda as irresponsible when the research methods are flawed, inappropriate research questions are investigated, or research that is irrelevant to anyone in the field is conducted.

Using Reeves' (1993, 1995) framework of pseudoscience, Lee (2005) identified some flaws in video-based learning research, such as specification error and inadequate sample sizes. This study analyzed four articles about video-based learning and provided aspects that should be included to foster a socially responsible agenda in video-based learning, such as planning and shooting educational videos and conducting telecommunication instruction (Lee, 2005). This type of critical analysis is one of the most outstanding needs in K-12 DGBL.

In instructional design and technology, many studies have been conducted to analyze factors beyond technology that play a role in effectiveness (Cennamo, 1993; Giannakos, 2013).

As Clark (1983) suggests, there are instructional factors that are actually responsible for effectiveness in learning that are not necessarily consequences of the use of technology. Some of these instructional factors are the use of two-way communication (Lee, 2005) and synchronous communication (Reeves, 2006). Other factors influencing effectiveness that have been found in the literature and are not necessarily related to instructional technology are motivation (Tsai et al., 2012), characteristics of the learner and the task (Cennamo, 1993), and learning involvement (Lim & Morris, 2009). Therefore, any study of instructional technology effectiveness should investigate these potential factors and features, which has not frequently been the case in DGBL.

It is necessary to evaluate and critique existing empirical K-12 DGBL evidence in order to generate a compilation of issues with current research that could help researchers and teachers improve it. Also, by doing this, a "socially responsible research" agenda (Reeves, 1995) will be generated, identifying trends and issues that should be studied and addressed when researching and implementing DGBL in K-12 classrooms. A socially responsible research agenda critically evaluates current empirical evidence and identifies problems with it, which makes research more reliable and valid (Reeves, 1993, 1995).

Furthermore, Reeves (2006) has explained that when studies are not critically examined to avoid pseudoscience, it is very difficult to conduct a valid literature review, since many studies should be rejected. This also makes it more difficult to establish generalizations about effectiveness. As a result of this, there has been growing skepticism in the field of instructional design and technology when there are claims about effectiveness in technology implementation (Reeves 2006), especially since many literature reviews draw conclusions about effectiveness on media comparison studies (Clark et al., 2015). The ultimate goal of a socially responsible research agenda is to inform researchers and practitioners about appropriate research designs that

should be conducted in the field of instructional design and technology (Reeves, 2006; Amiel & Reeves, 2008).

In addition, most literature reviews in DGBL focus on meta-analyses and systematic reviews, but not integrative literature reviews, which is a very specific and distinctive type of research methodology that creates new knowledge (Torraco, 2005). Meta-analyses and systematic reviews are quantitative in nature and combine primary data to summarize findings (Cook et al., 2013; Whittemore & Knafl, 2005). Conversely, the integrative literature review "reviews, critiques, and synthesizes representative literature on a topic in an integrated way such that new frameworks and perspectives on the topic are generated" (Torraco, 2005). The integrated literature review is a suitable alternative when there is a contradictory evidence in the literature. In the case of DGBL, even though there are studies that claim its effectiveness (Hitosugi, Schmidt, & Hayashi, 2014), other empirical data suggest that there is no impact in its implementation (Annetta, Minogue, Holmes, & Cheng, 2009). Also, the integrative literature review allows for the researcher to include different types of methodologies, while the systematic review or meta-analysis are quantitative (Whittemore & Knafl, 2005). Furthermore, the integrative literature review supports the creation of a new or emerging research agenda (Horne & Sandmann, 2012). Filling the gaps in instructional design and technology research presented by Reeves (1993, 1995, 2006), the integrative literature review can be a suitable methodology to produce a research agenda that complies with his principles of social responsibility in the field.

Since existing literature reviews in DGBL do not address the issues previously mentioned regarding effectiveness and media comparison studies and pseudoscience, as well as a socially responsible agenda, there is a need to use the integrative literature review to study these claims in K-12 environments specifically. According to data, there has been a declining achievement in K-

12 settings in the United States, which is another reason why it would be relevant to focus on learning and instruction for this population (Herrington, Reeves, & McKenney, 2011), especially with technology integration (Hew & Brush, 2007; Strycker, 2015). Also, a report of the Department of Education has pointed out the lack of rigor in empirical studies about the effectiveness of instructional technology in K-12 settings (Means, Toyama, Murphy, Bakia, & Jones, 2009). This report explains the need to also focus on this population, since it would not be appropriate to make generalizations for other settings (e.g. higher education) into this particular one.

Purpose Statement of the Study

The purpose of this study was to conduct an integrative literature review in a way that new knowledge is generated regarding how the effectiveness of DGBL in K-12 setting is studied, as well as identify possible problems and other influential factors in these empirical studies. While most reviews summarize, this integrative literature review synthesizes the literature. According to Torraco (2005), synthesis is "a creative activity that produces a new model, conceptual framework, or other unique conception informed by the author's intimate knowledge of the topic" (p. 362). Moreover, new perspectives are generated, even though the literature review still evaluates previous research (Torraco, 2005). After reviewing and evaluating existing K-12 DGBL empirical data, conceptual classifications and a research agenda were produced to inform the instructional design and technology community about the current state of K-12 DGBL research, the problems with it, and future directions to improve its implementation. This would make future research more reliable and rigorous, reducing potential threats to validity and the issue of pseudoscience (Reeves, 1993, 1995, 2006). On the other hand, it is relevant to study external factors and conditions that play a relevant role in instruction and are not necessarily

connected to the technology itself (Clark, 1983). This review paid special attention to these factors to inform researchers and practitioners of aspects that are effective when implementing a digital learning game. The study also looked to comply with the idea of a socially responsible agenda that takes into account the issue of pseudoscience, as stated by Reeves (1993, 1995).

Research Questions

This integrative literature review was guided by four main overarching questions:

1. How is the effectiveness of DGBL in K-12 being studied in empirical literature, including research designs, instruments, variables, and outcomes?
2. What problems are found in the literature regarding the study of effectiveness in K- 12 DGBL?
3. What factors or conditions might be influencing the effectiveness of K-12 DGBL in these empirical studies?
4. What areas or issues in K-12 DGBL still need to be studied in order to contribute to its effectiveness and advancement of the field?

This study followed the principles of an integrative literature review, which is qualitative in nature (Torraco, 2005; Whittemore & Knafl, 2005). In an integrative literature review, new knowledge is produced, instead of just a summary of the literature (Russell, 2005). The research design of this review was based on the work of Whittemore and Knafl (2005) and Cooper (1998), which includes the following steps: (1) problem identification, (2) data collection and evaluation, (3) data analysis, and (4) presentation of results.

The primary sources for this study are empirical studies in K-12 settings and the data analysis took a qualitative approach, with some minor quantifications (i.e. percentages, number

of published articles). Furthermore, six potential threats to validity in this study have been identified and addressed in Chapter 3.

Relevance of the Study

It is common in instructional design and technology to find several effectiveness claims in the literature when a new technology is integrated in instruction. That has been the case with television, video, computers (Reiser, 2001), and now with digital learning games (Prensky, 2001). This study analyzed empirical evidence in the K-12 DGBL literature in an attempt to evaluate if the claims of effectiveness are sound. Even though media comparison studies are not a recommendable method to study instructional effectiveness, many of the studies that claim effectiveness use this design (Annetta et al., 2009). On the other hand, some of the nine problems of pseudoscience (Reeves, 1993, 1995) previously described or any other research problems are still present in the research design of many of studies that claim effectiveness (Chen & Lee, 2018). By going back to individual studies and analyzing if there are problems with the research design, it is possible to determine the validity and reliability of the effectiveness claims for the DGBL K-12 literature.

In addition, it is relevant when addressing effectiveness in K-12 DGBL to identify other potential influential factors that have not been thoroughly explored in the literature, which is also one of the main goals of this study. This study also explored the potential factors that always play a role in instructional design and that are not only connected with the technology, such as types of communication in instruction (Reeves, 2006) or the characteristics of the learner (Cennamo, 1993).

Conducting this study, contributes to Reeve's (1993, 1995) socially responsible agenda in instructional design and technology, since a critical stand towards K-12 DGBL empirical

evidence was taken and resulting suggestions for research questions and appropriate research designs were made.

Organization of the Study

This study is presented in five chapters. Chapter One provides an overview of the study, including background, need for the study, and research questions. Chapter Two presents a literature review about the current state of DGBL and effectiveness studies in K-12 settings in order to situate this study and provide context. The purpose of this chapter is to inform researchers and K-12 teachers about the work that has been done and the outcomes of DGBL. Chapter Three presents the methodology used for this study, which is integrative literature review. In this chapter, the rationale for the decisions regarding methodology are discussed, as well as the procedures that guided the study and how data were collected, analyzed, and presented. Chapter Four shows the results of the study, based on existing empirical data . Finally, Chapter Five discusses the implications of the study and will offer general conclusions.

CHAPTER 2

LITERATURE REVIEW

Overview of DGBL

Even though there is no standard definition for DGBL, researchers have suggested that DGBL is the implementation of a digital game in instruction with clear learning outcomes (Chen, Liu, & Shou, 2018; Plass, Homer, & Kinzer, 2015). The origins of DGBL can be connected to the popularity of digital games in this era and the perceived advantages they can have in learning (Chaudhary, 2008; Gee, 2007; Prensky, 2001).

Historically, other popular technologies, such as television and computers, have also been incorporated in learning with the purpose of making instruction more effective and engaging (Gagne, 1987; Reiser, 2001). As a result, researchers have been constantly attempting to demonstrate the effectiveness of these popular technologies when implemented in the classroom (Bai, Pan, Hirumi, & Kebritchi, 2012; Kelly, Lyng, McGrath, & Cannon, 2009; Vrasidas & Solomou, 2013). DGBL has been no different, and for that reason, there are several studies in the literature that have strived to prove its effectiveness.

Studying Effectiveness

In general, effectiveness as a construct can vary according to the goal of the study; some studies have determined effectiveness in terms of an improvement in performance (Baker, Chow, Woodford, & Maes, 2012), while others have focused on skill acquisition (Yang, 2015), or changes in perception (Tsai, 2016). In the case of instructional design and technology, a common way of studying effectiveness is when a new instructional technology in the classroom is compared to traditional instruction, also known as media comparison studies, in order to analyze if said technology improved learning (Clark, 1983; Lockee et al., 1999). Regardless of the goal, a

common characteristic of effectiveness studies is analyzing how a change in behavior takes place after an instructional intervention.

Problems Studying Effectiveness

Clark (1983) and Reeves (1993, 1995) have specified the problems that can arise when studying the effectiveness of an instructional technology. Clark (1983) has stated that the instructional technology is simply a medium to deliver instruction and that it does not have an impact on learning. The claims in terms of effectiveness that are found in the literature are connected to the impact of novelty (i.e. using a new technology) and instructional method and not because instructional technologies or their attributes have a direct impact on instruction. Clark (1983) recognizes that "certain elements of different media, such as animated motion or zooming, might serves as sufficient conditions to facilitate the learning of students who lack the skill being modeled" (p. 453). However, he also explains that these "symbolic elements" in media (p. 452) or media attributes are not exclusive to any instructional technology, so it is not possible to connect effectiveness to a specific technology.

In addition, Clark (1983) points out that there are factors such as the external modeling of cognitive processes associated with a task, as well as what the teachers do during instruction that actually foster learning. For these reasons, using the media comparison approach to study effectiveness can be problematic and flawed. Even though Clark's (1983) position towards instructional technology has been widely accepted and replicated in the field, it is still common to see studies that use the media comparison approach or results from studies that state that a particular instructional technology fostered a change in learning and behavior (Clark et al., 2015). Other authors have also supported Clark's view, especially in terms of studies confounding media with instructional method or studies assuming elements and characteristics

are specific to one technology (Warnick & Burbules, 2007; Yengin, Karahoca, Karahoca, & Uzunboylu, 2011).

Other problems when studying effectiveness in instructional design and technology have also been identified by Reeves (1993, 1995). Reeves (1993, 1995, 2006) has questioned the relevance of research in the field, from the point of view of the questions that are investigated and the way that research is designed and conducted. Reeves (1993) has used the term "pseudoscience" when inappropriate research methods are used, sample sizes are not relevant, there are no strong connections to theory, the treatment duration is too brief, and other issues. Reeves (1995) has identified nine characteristics of pseudoscience. Table 1 shows these characteristics and their definitions.

Table 1

Characteristics of pseudoscience (Reeves, 1995).

Characteristic of Pseudoscience	**Definition**
Specification error	Vague definitions of the primary variables (e.g. learner control versus program control).
Lack of linkage to robust theory	Little more than nominal attention to the underlying learning and instructional theories that are relevant to the investigation.
Inadequate literature review	Cursory literature review focused on the results of closely related studies with little or no consideration of alternative findings.
Inadequate treatment implementation	Infrequent (usually single) treatment implementation often averaging less than 30 minutes.
Measurement flaws	Precise measurement of easy-to-measure variables (e.g. time); insufficient effort to establish the reliability and validity measures of other variables.
Inconsequential outcome measures	A lack of intentionality in the learning context, usually represented by outcome measures that have little or no relevance for the subjects in the study.

Inadequate sample sizes	Small samples of convenience, e.g. the ubiquitous undergraduate teacher education or psychology majors.
Inappropriate statistical analysis	Use of obscure statistical procedures in an effort to tease statistically significant findings out of the data.
Meaningless discussion of results	Rambling, often incoherent, rationales for failing to find statistically significant findings

Reeves (1995) stated that when studies are conducted with any of these characteristics of pseudoscience, a socially irresponsible research agenda is being pursued. A socially responsible agenda does not only avoid studies with any of these characteristics, but also focuses on research topics and questions that are relevant to the field (Reeves, 1995). Furthermore, Reeves (2006) explains that when studies have any of these characteristics of pseudoscience, they cannot be included in meta-analyses or other types of reviews, since they are flawed and it would not be appropriate to make any generalizations and claims when these problems are present.

When a new instructional technology is implemented in education, studies to determine effectiveness always follow (Reiser, 2001). For example, the effectiveness of mobile-based learning was studied in a quantitative study that used a pre/post-test survey to determine if students learned more and better than those in traditional classrooms (Suryaningrum, Wuryani, & Purbasari, 2015). The results of this study favored mobile-based learning over traditional instruction. In the case of video-based learning, a similar quantitative pre/post-test media comparison study was conducted, favoring the use of videos in instruction (Park, Kim, Cha, & Nam, 2014). However, Zhang, Zhou, Briggs and Nunamaker (2006) also investigated other factors that contributed to the effectiveness of video-based learning and found that interactivity played an important role in instruction and not the use of video alone.

Another example is the study of effectiveness of flipped classroom. These studies have only analyzed how student's grades changed over time and student's perceptions towards this instructional intervention. Results in this type of study have also favored flipped classrooms over traditional instruction, even though the authors have acknowledged the limitations of the study (Nwosisi, Ferreira, Rosenberg, & Walsh, 2016). Other attempts to determine the effectiveness of flipped classroom have used the media comparison approach with no significant improvement in outcomes or performance in students (Whillier & Lystad, 2015). The problem when using the media comparison approach to claim effectiveness in flipped classroom was pointed out in a study by Moraros, Islam, Yu, Banow, and Schindelka (2015) when their results showed that the use of critical thinking, interaction with peers, and self-directed learning played a higher role than the actual use of technologies associated with flipped classrooms.

In DGBL, effectiveness has been studied, but from the point of view of best practices (All, Nunez Castellar, & Van Looy, 2016). All et al.(2016) interviewed experts in DGBL research to find out about best practices when studying effectiveness and conducting related research. The main results of this study pointed out that when studying effectiveness, it is important for the researcher not to display too much control and to spend the same amount of time in the treatment implementation for both the control and experimental groups. Since one of the main goals of this dissertation is to examine the effectiveness of DGBL and how it has been studied, results of this review will be presented in Chapter 4, addressing DGBL effectiveness specifically.

Factors Influencing Effectiveness

As Clark (1983) has stated, it is relevant to take into account other factors that might influence effectiveness, as a result of the implementation of an instructional technology, but that

are not directly related to it. For example, Lim and Morris (2009) conducted a study to determine factors influencing learning outcomes within a blended learning instruction, finding that individual learning differences and characteristics, interactions, the type of learning activities, and motivation play a relevant role. Their results are consistent with other results found in the literature. Other factors that have been explored, which have not been related to the instructional technology per se, include factors influencing acceptance and perceptions of instructional technology (Fathema & Sutton, 2013; Israel & Moshirnia, 2012), motivation for learning (Suh, Kim, & Kim, 2010), satisfaction (Teo, 2010), levels of engagement in informal activities (Lohman, 2009), learners' preconceptions and invested mental effort in the use of instructional technology (Cennamo, 1993), and persistence in the use of instructional technology (Park & Choi, 2009).

Factors influencing the effectiveness of DGBL that have been found in the literature are prior knowledge, motivation for learning, and network speed (Suh et al., 2010), as well as the use of an authentic context for learning and availability of multiple resources (Laine, Sedano, Joy, & Sutinen, 2010). Moreover, Barendregt and Bekker (2011) found that when learners are presented with less freedom of choice or no freedom of choice at all when using a digital learning game in the classroom, their performance is better than those who are given no instructions or limitations in the use of the games. On the other hand, All et al. (2016) found that previous game experience, computer skills, characteristics of learners, and characteristics of the environment have a very influential role in the implementation of DGBL. Suh et al.(2010) conducted a study to determine if there was any relationship between effectiveness of DGBL and a wide variety of factors, such as gender, prior knowledge, motivation for learning, self-directed learning skill, computer skill, game skill, computer capacity, network speed, and computer accessibility. The

results of the study demonstrated that prior knowledge, motivation for learning, and network speed played a role in effectiveness, which indicates that other factors beyond the game can be responsible for any impact on learning due to games.

Dependent Variables Analyzed in K-12 DGBL Studies

Specifically addressing K-12 settings, DGBL studies have focused on different variables to determine effectiveness. Many of these variables have focused on effectiveness through changes in the knowledge, skills, and attitudes of students (Mavridis, Katmada, & Tsiatsos, 2017; Papastergiou, 2009). Furthermore, some studies have tried to look at effectiveness by focusing on the teacher's or student's levels of comfort, acceptance, or expertise with and after implementing DGBL (Bourgonjon, Valcke, Soetaert, & Schellens, 2010; Ketelhut & Schifter, 2011; Li, Lemieux, Vandermeiden, & Nathoo, 2013). The next sections will look at the different variables that have been studied in examining the effectiveness of DGBL in K-12 settings.

Engagement

Many studies in the K-12 DGBL literature have focused on engagement (Iacovides, Aczel, Scanlon, Taylor, & Woods, 2001; Ronimus, Kujala, Tolvanen, & Lyytinen, 2014; Schaaf, 2012). Engagement, in terms of education, can be defined as a type of bonding and attachment that students have with the school environment and the materials covered in classes (Jimerson, Campos, & Greif, 2003). Plass et al. (2015) identified four types of relevant engagement that should be taken into account when implementing and studying DGBL: affective engagement, behavioral engagement, cognitive engagement, and social/cultural engagement.

It is due to the perceived evidence that digital games increase engagement in students that this instructional trend has gained popularity in K-12 classrooms (Eseryel et al., 2014). There are claims in some studies that learners have experienced higher levels of engagement, which was

connected to a higher level of proficiency in the content of the lessons (Sabourin & Lester, 2014). In these studies, engagement is usually connected with higher levels of attention or increased interest in the courses and school activities (Hsieh, Lin, & Hou, 2015; Phillips, Horstman, Vye, & Bransford, 2014). However, it is important to point out that there has been evidence in the literature that suggest that there are external factors to the game, such as roleplaying and competition that are relevant for learning (Jabbar & Felicia, 2015). Also, as Clark (1983) has stated, higher level of engagements can be connected with the novelty effect that comes when a new technology is implemented.

Acceptance

The attitudes towards digital games have been a major concern for K-12 teachers and researchers. For this reason, several studies have been conducted to determine the levels of acceptance of digital games and the factors that play a role in students. Bourgonjon, et al. (2010) and Cheng, Lou, Kuo, and Shih (2013) focused on identifying the relationship between usefulness and ease of use of digital games to acceptance in K-12 students. These studies state that students have higher levels of acceptance when they find a game useful and easy to use. Also, the studies tried to find a direct relationship between acceptance and gender, which was not demonstrated, aligning also with other studies about gender and acceptance (Wang & Wang, 2008). However, the study by Bourgonjon et al. (2010) was not related to any DGBL intervention, but it was based on student's self-reports of previous experiences. In addition, there are claims in the literature that levels of acceptance are higher in the lower levels of K-12 education systems (i.e. younger populations) after digital games have been used as instructional interventions (Chen & Sun, 2013).

Higher-order Thinking Skills and Collaboration

One of the main arguments in favor of digital games is their ability to foster higher-order thinking skills in a more effective way than other traditional instructional interventions (Gee, 2007, Prensky, 2001). Higher-order thinking skills, which sometimes can be referred as 21st century skills, can include decision-making, creativity, analytical skills, and problem solving skills (Erstad, 2010). To determine the impact of DGBL in fostering these skills, research has been conducted in K-12 settings, especially because of evidence that these higher-order thinking skills are not regularly practiced in the classroom (Hommel, 2010). For example, creativity is one of the higher-order thinking skills that have been assessed through DGBL (Hsiao, Chang, Lin, & Hu, 2014). In this study, learners in an electrical science course had to demonstrate transfer of knowledge and creativity by making decisions and solving problems. Students were faced with scenarios and they had to find ways to apply knowledge in the game to move forward. The Creativity Assessment Packet (CAP) was used to measure creativity in this study. This is consistent with other digital games where students face challenges and have to think about strategies and alternatives to overcome them (Thomas, Ge, & Greene, 2011). Using digital games, students have demonstrated that they apply creative strategies and problem-solving skills, using knowledge from the lesson. This has taken place because students have an opportunity to perform in more realistic scenarios, compared to more traditional assessments, such as test or quizzes (Huang et al., 2014).

By using regression and correlation analyses, researchers have tried to connect how overcoming obstacles and moving forward through the game implied a use of some conceptual knowledge and creative strategies. For instance, Hsiao et al. (2014) gathered data from the Creativity Assessment Packet (PAC) to correlate DGBL interventions to creativity.

Studies also claim that using digital games promotes anxiety-free environments that allow students to improve their performance and apply with more confidence higher-order thinking skills (Gresham, 2009). The application of higher-order thinking skills, as well as DGBL in general, often implies the use of collaboration in the classroom. For this reason, analyzing how digital games promote collaboration in the classroom has been one of the outcomes of research in the field. Throughout observations and interviews with gamers, studies have been able to understand how using a digital game promoted working in teams and sharing game strategies, which had not taken place in other instances, according to some empirical data (Sardone & Devlin-Scherer, 2010). Furthermore, there are claims that the use of digital game environments facilitates collaboration in high levels, when compared with more traditional educational projects or interventions (Sung & Hwang, 2013).

Content Knowledge

Another way to study effectiveness in DGBL is through the assessment of content knowledge. To determine the potential of digital games in helping students master learning objectives, some studies have used different assessments to see if students became better after the game in terms of content. In most studies, an experimental group is asked to play a game, whereas a control group uses traditional instructional techniques to see which group does better on a test (Annetta et al., 2009). This type of study is known as media comparison study, but it could be problematic because certain elements and attributes can be found in many media and not in just one (Clark, 1983). In addition, the popularity of digital games and other types of social activities add a factor of novelty to conventional instruction, which can be translated in higher levels of engagement and achievement, even though it is not necessarily because of the instructional value of the digital learning game (Clark, 1983).

It is important to point out that although there is evidence that in some instances, students in the experimental DGBL had better performance than those in the control group (Huizenga, Admiraal, Akkerman, & ten Dam, 2009), in other studies the use of DGBL had no significant difference from other instructional interventions. For instance, in a study conducted in K-12 science classrooms, teachers used a digital game to review concepts related to genetics (Annetta et al., 2009). After the game intervention, the control groups and the experimental groups were given a post-test to assess their knowledge about the lesson. The results of the study showed that there were no significant differences between groups in terms of mastery of knowledge, even though the experimental group showed higher levels of engagement, based on an observation protocol. The authors of the study recognized that due to the short duration of the intervention, the study is not rigorous, especially because students had to spend large amounts of time simply learning how to play the game. The issue of having DGBL interventions that are too short has also been a threat in other studies (Huizenga et al., 2009) and is one of the characteristics of pseudoscience (Reeves, 1995). As previously mentioned, when contradictory evidence is found in the literature, an integrative literature review is a more convenient way to evaluate and review data, instead of summarizing it with studies that share similar outcomes (Torraco, 2005).

Reviews of DGBL Literature

The effectiveness of DGBL has also been claimed in the instructional design and technology literature. Since the goal of this dissertation is to thoroughly analyze the K-12 DGBL literature, study by study, this section of the literature review will focus on a summary of other DGBL reviews that have tried to study effectiveness. The results of the integrative literature review that was conducted in this dissertation will be presented in Chapter 4.

In the DGBL literature, literature reviews, meta-analyses, systematic reviews, and integrative reviews are found (Clark et al., 2015; Giannakas, Kambourakis, Papasalouros, & Gritzalis, 2018; Tan, Lau, Liau, 2017; Tsai & Fan, 2013; Wu, Hsiao, We, Lin, & Huang, 2012). A literature review simply summarizes the current state of a body of literature and is used to give context to a research issue (Russell, 2005). On the other hand, systematic reviews attempt to find answers to specific questions, by analyzing studies that address similar problems and questions in an effort to reach generalizations (Whittemore & Knafl, 2005). They can be quantitative if there is homogeneity in the methodologies of the study or qualitative if it is not the case. Moreover, a meta-analysis is quantitative in nature and concerned with using statistical procedures to calculate an overall effect size, which, in the case of instructional technology, can be measuring the impact that an instructional technology had over learners or over other instructional methods (Mesmer-Magnus & Viswesvaran, 2010; Whittemore & Knafl, 2005). Finally, integrative reviews evaluate and critique existing literature with the purpose of generating new knowledge or conceptualizations, based on existing empirical data (Torraco, 2005). The ability to produce new perspectives on a topic is the main differentiator between integrative reviews and other types of reviews.

Literature Reviews

Researchers have used literature reviews in an attempt to summarize studies conducted in DGBL (Hwang & Wu, 2012; Tsai & Fan, 2013) and provide an overview of the state of the literature. Tsai and Fan (2013) conducted a quantitative review of 24 papers from the Social Science Citation Index (SSCI) and determined that the study of DGBL has drastically increased in the past 10 years. According to this study, secondary school students and higher education students, specifically undergraduates, are the populations that have been used the most to study

DGBL. Furthermore, the review shows that science and social sciences are the subject domains that are used the most when implementing DGBL. As far as research design goes, this study shows that most DGBL are quantitative in nature, with some instances of mixed methods. The authors did not find any empirical studies using a qualitative approach. Specifications about how the studies took place or details about their research design was not available.

A similar literature review, conducted by Hwang and Wu (2012) also found that the amount of studies in DGBL have increased in the past years and that more countries around the world are implementing digital learning games. However, this literature review presents contradictory evidence from the study conducted by Tsai and Fan (2013), since it shows that the populations that has been studied the most is higher education students. Another finding in this literature review was that most studies do not focus on cognitive domains, but on perceptions, acceptance, and attitudes towards digital learning games.

Hainey et al. (2012) conducted a literature review of 21 papers, out of 903, that were selected based on their evidence of use of DGBL assessments or DGBL assessment models. The goal of the authors was to build a preliminary DGBL assessment model, based on finding from other studies. The results of this study does not show any quantitative information, but rather a list of findings in terms of instruments and strategies used for assessment. The findings of this literature review points out that quizzes, peer reviews, formative assessment, summative assessment, and the use of rubrics are the techniques used for DGBL assessment. This information was used by the authors to build a preliminary DGBL assessment framework with the following steps: planning, design, gameplay, and debriefing. However, there is no specific information on how data from the literature played a relevant role in the development of this framework or the research validity, reliability, or design of the studies.

Also examining the topic of DGBL assessments, Bellotti et al. (2013) conducted a literature review that offered an overview of assessment of DGBL. This literature review is narrative and descriptive in nature with no information on how studies were selected to conduct the review or any information about the research designs of those studies. The literature review makes a case for the importance of assessing learning with digital games in the classroom and it provides examples from the literature, such as the use of iClickers, using features from the game to assess, or questionnaires. However, it is not possible to make connections between the claims of the review and existing empirical data, since a methodology section is not included.

Chin et al. (2009) also conducted a literature review about the history of assessment in DGBL. In their review, evidence from the literature establishes the need to assess digital learning games and they discuss strategies that have been implemented, such as self-assessments and ungraded post-activity surveys. Even though this review is descriptive in nature and does not provide a thorough methodology section, it points out that there are many methodological problems, such as lack of rigor and lack of theoretical connections, in the study of DGBL.

Divjak and Tomic (2011) conducted a literature review of 27 studies focusing on the impact that learning digital games had on learning outcomes and motivation in mathematics education. The results of this literature review showed that the country with the highest level of DGBL implementation in mathematics education is the United States and that the population that has been studied the most is primary school students. The results of this review is consistent with other studies that show that quantitative methods are the most common ones when studying DGBL implementation. Also, 21 out of the 27 studies showed that digital learning games can have a positive impact on learning outcomes for students. Other results of this literature review point out that digital learning games have a positive impact on student's motivation towards

learning mathematics, since 14 out of 17 studies addressing this issue showed positive results. This study does not address how the evaluation of data took place and how the determination of positive or negative impact was determined by the researchers. Also, there was no information about the types of studies selected to conduct the study.

Li and Tsai (2013) also conducted a similar literature review, but focused on science education. The authors reviewed 31 papers, pointing out that many of them could not be considered since they did not use an empirical methodology in the study. This study focused on the research purpose of DGBL studies in science education, showing that the most common purpose is the evaluation of DGBL implementation, while media comparison studies between digital learning games and traditional instruction were the second most common trend. In addition, this study shows that having learners participate in game design is not a common trend in DGBL implementation, since only two studies used this approach, while all of the others require the learners to just play the game. Twenty studies had a theoretical foundation; 19 of them used cognitivism, constructivism, or a combination of both in the design and implementation of the digital learning game. This literature review also shows the majority of studies focused on science knowledge/concepts (n=27). Problem-solving and engagement were also the foci of some studies included in this review.

Meta-analyses

Tsai and Tsai (2018) conducted a meta-analysis of 26 studies to study the effectiveness of DGBL in vocabulary learning. As part of the findings of the study, they were able to demonstrate that digital games can foster motivation and enhance the learning process in students. Furthermore, this meta-analysis allowed them to develop a framework to connect different factors of DGBL to specific outcomes mastered by learners.

In another study, Byun and Joung (2018) conducted a meta-analysis of 33 empirical studies that focused on mathematics. They looked at achievement and effect size, as well as possible directions for research, based on their findings. Even though the authors found potential effectiveness in the use of digital learning games in mathematics, they recognized that it was difficult to make generalizations because there were not enough empirical studies or statistical data to do so. The authors recommended to conduct more rigorous empirical studies and to diversify the types of games used in mathematics instruction since most them were based on drill and practice.

Wu et al. (2012) conducted a meta-analysis to study the theoretical foundations used in DGBL. In this analysis, 658 studies were used to determine how the use of learning theories is used in the design and implementation of DGBL. This analysis shows that 567 studies failed to use a learning-theory foundation. From the remaining 91 studies, constructivism is the learning theory that is used the most to inform the design and implementation of DGBL. Even though the goal of the authors was to conduct a meta-analysis, as stated in the information of the article, the study was a literature review because no statistical analysis was conducted to calculate size effects that would allow for generalizations.

Systematic Reviews

Sousa and Costa (2018) conducted a systematic review with 14 peer-reviewed journal articles to analyze the effect-sizes of game-based learning in comparison with other traditional methodologies. Results of this systematic review favored the use of digital learning games for instruction over other methods. One limitation in this review, as pointed out by the authors, was the heterogeneity of the populations and contexts used to conduct the study. For this reason, even though claims of effectiveness are made based on calculations of effect-sizes, it is difficult to

make generalizations since too many diverse factors could have had an impact on the effectiveness of learning.

All et al. (2014) conducted a systematic review of 25 studies to find an overarching methodology to assess the effectiveness of DGBL. In this review, the researchers focused on studying the types of participants, the interventions (i.e. interventions in the control group when implementing DGBL), research methods used in DGBL studies, and outcomes measures and results. A Cochrane method was used to determine generalizations based on existing studies. The results of this study showed that DGBL projects take place the most in schools and in school related activities and its study in informal contexts is not common. In terms of intervention, this study revealed that digital learning games are usually implemented in traditional classroom teaching, using a media comparison approach. This review pointed out that when media comparison studies have been conducted to determine DGBL effectiveness, some of the interventions that the control group has used have been computer-based learning, paper and pencil exercises, or traditional multimedia classroom teaching; whereas the experimental group used a digital learning game. Another important finding of this systematic review is that almost all of the studies used an experimental research design and almost all of them used a quantitative or mixed method approach, while only 3 out of the 25 studies used a qualitative research approach. Finally, the majority of measurement instruments of these studies were tests developed by the researchers and school tests or exams.

On the other hand, Clark et al. (2015) conducted a systematic review and meta-analysis for K-16 DGBL. This review and analysis used a media comparison study approach to compare outcomes of game and nongame conditions. As typical in systematic reviews, the authors established some core hypotheses before conducting the study: (1) they predicted that digital

learning games would be associated with better learning outcomes than traditional instruction, and (2) they predicted that augmented reality game designs would be associated with better learning outcomes than standard versions of those games. The authors defined augmented reality games as those that take place in a real world environment and not through a digital device. In this study, the authors used robust variance estimation (RVE) in meta-regression. The authors recognized that one of the challenges when conducting the study was that many studies could not be included because of their inadequate research design (i.e. only 69 out of 1,040 studies could be included). With those 69 studies, the researchers had 6,868 unique participants for this systematic review and meta-analysis. The results of this review favored DGBL implementations over traditional instruction with a 0.33 standard deviation improvement, which was consistent with prior meta-analyses (Sitzmann, 2011; Vogel et al., 2006; Wouters, van Nimwegen, van Oostendorp, & van der Spek, 2013). However, the authors pointed out that there was no significant difference in terms of motivation between DGBL implementations and traditional instruction. Also, this study favored augmented game designs over standard versions of those games with a 0.34 standard deviation improvement.

Another systematic review was conducted by Connolly, Boyle, MacArthur, Hainey, and Boyle (2012). In this study, 129 articles were reviewed, showing that 121 used a quantitative methodology, while only 8 used a qualitative one. This trend has been consistent throughout the DGBL review literature. Another finding of this review is that most studies in the literature focus on games for entertainment (n=68), but it is not significantly different compared to the study of learning games (n=49). This study also showed that action games are the ones the most implemented and that the health sciences are the ones who implement digital learning games the most, followed by social science and science. This study also showed that the claims in the

literature about the impact of digital learning games on high order thinking and soft social skills were not supported by strong empirical data. These claims are usually made in a qualitative fashion with no experimental evidence.

Jabbar and Felicia (2015) conducted another systematic review focusing on learning outcomes and student engagement when implementing DGBL. The authors reviewed 91 articles, showing that 55% of them focused on primary education. Furthermore, the authors used a scoring system, based on a maximum value of 15, to determine the quality in the research design of these studies. The authors found that only 34 papers were considered of high quality in terms of research design, whereas the majority (n=47) were of fair research design quality. According to the authors, those studies with the highest level of quality followed an experimental design methodology. The specifications of this scoring system was not provided in the study. Results from this study point out that skill acquisition and knowledge acquisition are the two main results of the implementation of DGBL, since both areas had almost a 50% presence in the literature, based on these 91 studies. Consistent with other studies, this review shows that science is the domain most often used to implement DGBL. Finally, in terms of engagement, this study connects engagement with other factors within the game, such as role-playing, competition, the use of visuals, and animation. This establishes the need to explore in further detail the factors that play a relevant role in the implementation of DGBL.

Integrative Reviews

In the DGBL field, integrative reviews have also been identified. Tan et al. (2017) conducted an integrative review of 26 journal articles about the use of serious games in nursing education and how the games that are used in this field have contributed to the fostering of

specific skills in students. The review clustered the studies into four main themes: procedural skills, health assessment skills, communication skills, and clinical reasoning skills.

Another integrated review in DGBL for nursing education studied 10 journal articles to identify themes in empirical data about the use of games with nursing students (Neves da Nova Fernandes & Ângelo, 2018). The four main themes in which these articles were clustered are: types of games, focus of the game, methods for evaluation of the strategy, and scope of games.

Dias, dos Santos Tibes, Fonseca, and Zem-Mascarenhas (2017) conducted an integrative review with 17 journal articles in the field of nursing education as well. In this review, ten studies were clustered into two main themes: the use of serious games to cope with childhood obesity and the use of exergames to cope with childhood obesity. By conducting this type of review, authors were able to find types of games that have helped children cope with obesity problems, which has provided new knowledge to nursing students.

Summary

Based on the results of these reviews, there is a clear need to conduct more qualitative analyses in order to describe how effectiveness has been demonstrated in studies that make these claims. The integrative literature review methodology, almost unexplored in DGBL, can be a suitable alternative to critique and evaluate studies that make claims about effectiveness. Many of the existing reviews have made generalizations, but they have the problems of including media comparison studies and studies with other characteristics of pseudoscience (e.g. lack of theoretical foundations or inadequate research designs), as defined by Clark (1983) and Reeves (1993, 1995). A review to make generalizations cannot be conducted if a critical analysis of the reliability and validity of the data is not carried out, which is why many papers are rejected when conducting these reviews. Also, these reviews do not study in depth other possible factors that

might be playing a role in the implementation of DGBL, which is very relevant in instructional design and technology.

Even though some integrative reviews have been conducted in the area of DGBL, they have not been numerous and they have only focused on the nursing education field. For this reason, there is a need to use this methodology to investigate other areas of DGBL and other subject matters. According to data, there has been a declining achievement in K-12 settings in the United States, which is one reason why it would be relevant to focus on learning and instruction for this population (Herrington et al., 2011). Focusing on one specific population would allow for more effective generalizations and implementation for teachers and researchers.

Measurement Instruments

In order to study the effectiveness of DGBL, it is important to develop familiarity with the instruments that have been used for this purpose. The following section presents an overview of the instruments that have been used in DGBL effectiveness studies, which are usually quantitative in nature (All et al., 2014; Connolly et al., 2012).

Surveys

Surveys have been one of the most common ways to assess learning and other skills and attitudes in K-12 students involved in DGBL (Afari, Alridge, & Fraser, 2012; Cheng et al., 2013; You, Kim, & No, 2015). In most instances, survey instruments are used after a DGBL intervention (Chen & Sun, 2013). However, there are cases in which the use of a survey instrument does not follow a DGBL intervention to assess content, but they are used to examine other constructs such as acceptance or level of comfort with games (Bourgonjon et al., 2010). Although most of the surveys used to assess performance and attitudes in DGBL are external, there have been instances in which the survey has been embedded in the game. However, the

survey was not actually part of the game or related to its content; instead, learners were asked questions about reactions and overall experience playing the game (Ronimus et al., 2014).

In the instances of surveys used to assess affect, there are well-recognized surveys that have been used in DGBL studies, such as the Big Five Personality Questionnaire (Nagle, Wolf, & Riener, 2016), the Cognitive Emotion Regulation Questionnaire (Sabourin & Lester, 2014), the Performance Measure of Persistence (Ventura & Shute, 2013), or the Intrinsic Motivation Inventory (Mihelj et al, 2012). Table 2 shows some sample questions and statements in these surveys.

Table 2

Sample Questions/Statements of Survey Models.

Survey	**Sample Questions/Statements**
Big Five Personality Questionnaire	I am interested in people I have difficulty understanding abstract ideas I pay attention to details I get upset easily
Cognitive Emotion Regulation Questionnaire	I think of what I can do best I think I can learn something from the situation I often think about how I feel about what I have experienced
Intrinsic Motivation Inventory	I enjoy doing this activity very much I think I am pretty good at this activity It was important to me to do well at this task I was anxious while working on this task

Pre-tests and Post-tests

In order to determine if a change in performance or knowledge acquisition has taken place after DGBL has been implemented, pre-tests and post-tests with questions related to the content of lessons have been used. Some studies have used pre-tests and post-tests with the same

identical questions to assess the specific information that students have mastered after the instructional intervention (Chang et al., 2015; Papastergiou, 2009; Sabourin & Lester, 2014). In some studies, only post-tests are used after students have played a digital game that is related to the content of a lesson for a large amount of time (Huizenga et al., 2009). Most of these tests are written in nature; however, depending on the topic, they can be oral in nature to assess proficiency in topics such as reading (Ronimus et al., 2014).

Observations Protocols

Observation protocols have been widely used especially to assess levels of engagement and effectiveness of DGBL (Rosa, Ridgers, & Barnett, 2013). In many cases, teachers and researchers have designed and developed their own observation protocols (Huizenga et al., 2009; Rosa et al., 2013). However, due to growing use of observations in DGBL, some protocols such as the Protocol for Classroom Observation have been designed (Anetta et al., 2009). Some of the items of this protocol require teachers to observe and report on aspects such as: description of the room, amount of time students spend paying attention to an activity, time students spend collaborating with each other, amount of time students take to answer questions, instances of need for cues or help from teacher, etc. Observations can also be in digital format (i.e. recorded observations), which can help the teacher or researcher capture more information and put the learner at ease since they are more non-intrusive in nature (Brom et al., 2010; Shah & Foster, 2014).

Interview Protocols

In addition, to understand the rationale behind choices in gameplay and game design in students, interviews have been used extensively in DGBL studies (Baytak & Land, 2010; Sardone & Devlin-Scherer, 2010). The goal of many of these interviews has been to understand

the perceptions of students as they are using the game and how they influence the learning process (Huang et al., 2014). In other instances, an interview is used to understand the process of changes in knowledge, skills, abilities, or learning (Hung, Young, & Lin, 2015).

Data from Digital Game

Data from digital games have been used to analyze the changes that can take place in instruction when a digital game is implemented (Evans et al., 2015) or to study changes in learning when students engage in game design (Wu, Chen, Wang, & Su, 2008). Digital games have enormous potential for collecting large amounts of data that can predict performance and track progress in students because of the embedded features within the game, such as scores, time vs. task completion records, or log shifts (Almond, Kim, Velasquez, & Shute, 2014). These data can help teachers determine the areas in which students are struggling the most and/or who are the most experienced gamers in the classroom (Evans et al., 2015; Evans, Pruett, Chang, & Nino, 2013). In addition, using a digital game to provide feedback to students during the learning process has been effective and it has contributed to relevant changes and knowledge acquisition (Erhel & Jamet, 2013). Therefore, teachers should be prepared to use feedback from the games in their classrooms to help students experience success. Some studies have focused on the relevance of embedded assessment when designing a game, but from the perspective of game designers alone, not teachers (Almond et al., 2014).

Rubrics

To support the implementation of DGBL in K-12, a number of digital games evaluation rubrics have been developed. Generally, these rubrics are found in websites focused on DGBL, but are not grounded on research or empirical evidence. Also, they do not provide specific information about assessing students; instead, they focus on how teachers can evaluate a digital

game, based on some features of it, such as visual design and navigation. However, these rubrics do not address the procedures or types of instruments that have been or should be used to assess students through DGBL. There are in the literature rubrics that have used in project-based learning projects and simulations that could be further implemented in DGBL (Martinez, Herrero, & de Pablo, 2011).

Models and Frameworks

The interest in the study of DGBL effectiveness has also contributed to the development of models to guide teachers and researchers in the process of implementing DGBL and assessing the effectiveness. They have been used as guidelines to inform teachers on how to adopt and integrate digital games in their classrooms. Some of the models that have been used in DGBL to inform and understand the assessment processes are the Input/Process/Output Game Model (Hainey et al., 2012) and the Play Curricular activity Reflection Discussion (PCaRD) pedagogical model (Shah & Foster, 2014).

Hainey et al. (2012) developed a preliminary model for integrating assessments in DGBL, based on the Input/Process/Output Game Model that was described and illustrated by Garris, Ahlers, and Driskell (2002). This preliminary model focuses on four stages that should be taken into account when implementing a digital game: planning, design, game play, and debriefing. Although the model offers a solid structure that guides teachers from the first phase of figuring out the alignment of a digital game with learning objectives to the reflection that should take place after game takes place, the model does not offer specific guidelines on how to use the affordances of the game to make direct connections with the content or how to use the embedded features or data from the game to assess performance.

Similar to this model, the Play Curricular Activity Reflection Discussion (PCaRD) pedagogical model has offered guidance to K-12 teachers in identifying effective sets of activities to assess the performance of learners (Shah & Foster, 2014). According to this model, after students spend a lot of time playing a game, teachers introduce the content of the lesson, followed by a time to reflect on the connections between the game and lesson. They conclude with a discussion activity, where students can discuss best practices during the game or the most salient information they learned throughout the process. The stages of this model are similar to those of the preliminary model developed by Hainey et al. (2012).

In terms of game design, there are models that inform the characteristics that effective digital games should have to provide appropriate feedback to students, such as the Experiential Gaming Model (Kiili, 2005). This model uses flow theory to describe that process that should take place while a student is playing a game and the right opportunities to provide feedback and allow experimentation and reflection. The model has been mainly used for game design, but it can also inform teachers about the dynamics of digital games and how they play an important role in the cognitive processes of students. However, from the practical point of view, the model is too abstract for teaching practices and does not offer recommendations or guidelines about how to make connections between the game and the content, or how to use the game and data from it to assess the performance of student or effectiveness in instruction after implementation of DGBL.

The literature about these models is not extensive; these models for DGBL assessment have not produced relevant empirical data and have not guided a large amount of studies. The models do not provide extensive information about tools and strategies for assessment. For all these reasons, therefore, it is hard to connect them to effectiveness of DGBL.

Summary of the Chapter

This Chapter has given context to the research problems and need for the study stated in Chapter 1. Similar to other instructional technologies, researchers have been constantly trying to study the effectiveness of digital learning games since DGBL started gaining popularity in instructional design and technology. Even though effectiveness, as a construct, can have different interpretations to different researchers, so far the construct has been identified in the DGBL literature as a change in learning, behavior, or attitudes during instruction. The literature on DGBL effectiveness has covered different populations, including K-12 students, higher education students, and adults. DGBL studies are currently conducted in a wide variety of countries around the world.

However, the field of instructional design and technology has witnessed some problems in the study of effectiveness. One of the most common problems in the study of instructional technology effectiveness is the use of media comparison studies (Clark, 1983) and the presence of any of the nine characteristics of pseudoscience as described by Reeves (1993, 1995): specification error, lack of linkage to robust theory, inadequate literature review, inadequate treatment implementation, measurement flaws, inconsequential outcome measures, inadequate sample sizes, inappropriate statistical analysis, and meaningless discussion of results. By avoiding these problems, researchers will pursue agendas that are socially responsible, as stated by Reeves (1993, 1995).

In addition, another aspect that is important to take into account when conducting effectiveness studies in instructional design and technology is the presence of factors external to the technology that might influence learning and achievement. Some of the factors that have been identified are the individual characteristics of the learner, the characteristics of the task,

motivation in the learner, perceptions about the usefulness of the technology, and the instructional method (Cennamo, 1993; Clark, 1983, Tsai et al., 2012). One of the problems in the DGBL literature is the lack of a strong presence of studies focusing on these factors.

Due to the large amount of DGBL studies, several reviews have been conducted: literature reviews (Chin et al., 2009), systematic reviews (Clark et al., 2015), and meta-analyses (All et al., 2014) with different goals. Mostly, these reviews have focused on summarizing the state of the DGBL literature and using quantitative techniques to make generalizations in terms of effectiveness. Some of the variables used in these reviews are engagement, gender, persistence, and the effectiveness of digital learning games over traditional instruction (Iacovides et al., 2001; Mavridis et al., 2017; Wang & Wang, 2008). Many of these reviews analyze any population, which is problematic when trying to draw conclusions and make generalizations, since each population has different conditions. On the other hand, these DGBL reviews have studied how assessments have been used to determine effectiveness and some assessment models have been developed as a result of these reviews (Hainey et al., 2012). However, there is no presence of integrative literature reviews addressing specific problems or evaluating existing studies and most DGBL studies are quantitative or mixed in methodological nature (Tsai & Fan, 2013). Since many studies used to conduct these reviews can have any of the problems in instructional design and technology research previously mentioned, it is pertinent to use the integrative literature review to identify these potential threats to validity.

Specifically addressing K-12 populations, studies have focused on how digital learning games have influenced levels of engagement, acceptance towards games (Bourgonjon et al. 2010), high order thinking skills and collaboration (Hsiao, Chang, Lin, & Hu, 2014), and content knowledge (Annetta et al., 2009). In studying these changes, a wide variety of instruments have

been used, such as surveys (Afari et al., 2012), observation protocols (Rosa et al., 2013), interviews (Baytak & Land, 2010), and pre-tests and post-tests (Chang et al., 2015). In addition, data from the actual games have been collected to determine the effectiveness of these games (Almond et al., 2014).

The literature review conducted in this chapter establishes a need to thoroughly evaluate and critique existing empirical data in K-12 settings specifically, identifying if any of the problems in instructional design and technology research is affecting these effectiveness claims. In addition, this chapter establishes the need to study how factors external to digital learning games can be playing a role in instruction and are responsible for effectiveness. For this reason, an integrative literature review will be conducted with the goal of filling these gaps in the literature and producing a socially responsible and appropriate research agenda for those interested in continuing the study of this instructional trend. The next chapter will address how this methodology will be carried out.

CHAPTER 3

METHODOLOGY

Introduction

This chapter describes how the integrative review was conducted. Having a detailed methodology chapter, following accepted conventions for research and report, is a very important step in this kind of study, so sufficient information is provided to determine how the researcher evaluated evidence and drew conclusions (Torraco, 2005).

Purpose

The purpose of this study was to conduct an integrative literature review related to K-12 DGBL in order to produce new knowledge about how its effectiveness has been studied, as well as potential problems in those research studies. In addition, this review studied the factors that could have played an important role in these claims about effectiveness. Finally, this study proposes a research agenda with areas and issues in K-12 DGBL that should be further investigated.

By definition, "the integrative literature review is a form of research that reviews, critiques, and synthesizes representative literature on a topic in an integrated way such that new frameworks and perspectives on the topic are generated" (Torraco, 2005, p. 356). The integrative literature review has been used in a wide variety of disciplines to conceptualize new topics or to provide new frameworks and perspectives for mature topics (Mokel & Sheliman, 2013; Walker, Broderick, & Sque, 2013; Whittemore & Knafl, 2005). Torraco (2005) has stated that when a topic is mature and has been extensively studied, it is necessary to make re-conceptualizations, evaluations, or critiques of it. The K-12 DGBL literature can be considered a mature topic since it has been studied for years and several reviews have attempted to draw generalizations thus far.

For this reason, it was pertinent to evaluate and critique existing empirical data to determine the foundation of the effectiveness claims in K-12 DGBL.

The integrative review has distinct characteristics and should not be confounded with similar review methodologies, such as meta-analyses, systematic reviews or literature reviews (Whittemore & Knafl, 2005). A meta-analysis "combines the evidence of multiple primary studies by employing statistical methods," while a systematic review focuses on "a specific clinical problem to inform clinical practice" (Whittemore & Knafl, 2005, p.547). A literature review is used to give context to a research problem, by summarizing an existing body of knowledge (Russell, 2005). In these instances, the purpose is to summarize what has been done and provide generalizations; however, an integrative literature review seeks to produce new knowledge, synthesize, and critique in a qualitative manner (Cooper, 1998). Another characteristic of the integrative literature review, similar to other qualitative methods, is flexibility (Cooper, 1998). The research questions, as well as other steps in the design of the methodology can evolve as the researcher starts working with the data.

As Torraco (2005) has described, there are four common forms to synthesize findings in an integrative literature review: (1) a research agenda, (2) a taxonomy or other conceptual classification of constructs, (3) an alternative model or conceptual framework, and (4) a metatheory. For this study, conceptual classifications of constructs and a research agenda were produced to synthesize results. These classification schemes were designed to visually display the findings of the study, as it has been done in other integrative literature reviews studies (Johnson, 2010). The research agenda was created as a narrative that presents gaps in existing empirical research and questions that need to be investigated in K-12 DGBL, as well as other pertinent information for researchers. The presentation of a research agenda with potential

questions, suggested research designs, and implementation strategies has been identified as an appropriate outcome in other studies (Eccles et al., 2009; Lee, 2005; Lockee et al., 1999).

The overarching research questions for this study are:

1. How is the effectiveness of DGBL in K-12 being studied in empirical literature, including research designs, instruments, variables, and outcomes?
2. What problems are found in the literature regarding the study of effectiveness in K- 12 DGBL?
3. What factors or conditions might be influencing the effectiveness of K-12 DGBL in these empirical studies?
4. What areas or issues in K-12 DGBL still need to be studied in order to contribute to its effectiveness and advancement of the field?

Research Design

One of the particularities of integrative literature reviews is that they allow for the researcher to include and analyze diverse methodologies (e.g. quantitative, qualitative data, mixed methods, etc.) and present results in any of these formats (Bartlett, Boylan, & Hale, 2014; Whittemore & Knafl, 2005). For this study, quantitative, qualitative, and mixed empirical data were used and the results are presented in a qualitative format, with some minor quantifications (e.g. article count by country, quantification of studies by subject matter, etc.). This type of presentation of results has been used in other integrative literature reviews that are qualitative in nature (McLeod, Barr, & Welch, 2015; Singh & Hardaker, 2014).

For the design of this integrative literature review, the five stages for integration process proposed by Whittemore and Knafl (2005) and based on Cooper's (1998) framework, were used: (1) problem identification, (2) data collection, (3) data evaluation, (4) data analysis, (5) and

presentation of results (Whittemore and Knafl, 2005). However, in this study, the data collection and data evaluation stages took place simultaneously; therefore, they were combined into one step. Figure 1 presents this research design process and Table 3 presents the tasks related to each of these stages in this study. These tasks were identified based on Whittemore and Knalf's (2005) and Torraco's (2005) model, as well as through an examination of similar integrative literature reviews (Carlisle, McBride-Chang, Nagy, & Nunes, 2010; Echenique, 2014; McLeod et al., 2015; Tarique & Schuler, 2010).

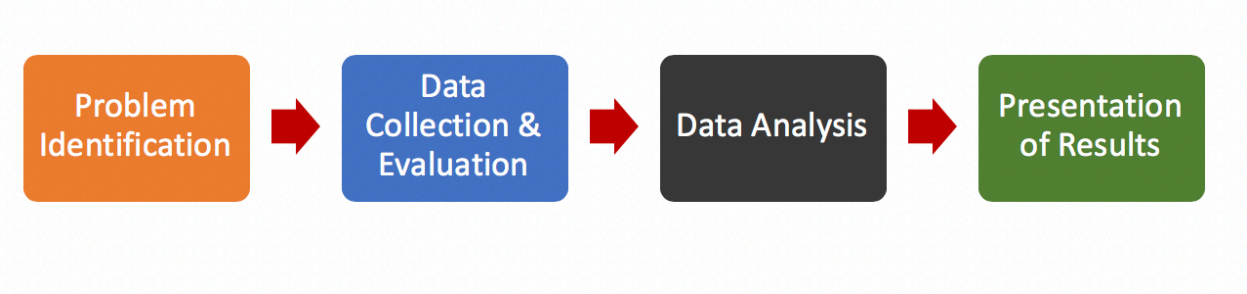

Figure 1. Stages of research design for this study.

Table 3

Stages and tasks in integrative literature review.

Stage	**Tasks**
Problem Identification	Identify problem in the literature Identify adequate theoretical framework/foundation Determine purpose of the study Develop research questions Determine finalized product for the integrative review
Data Collection and Evaluation	Define search criteria Identify potential alternatives to search criteria Select adequate databases Initiate search Use search criteria to classify and filter studies Report on criteria for data evaluation
Data Analysis	Determine initial codes

	Open coding Data comparison and axial coding Conclusion drawing and verification
Presentation of Results	Write results Create conceptual classifications Write research agenda

Problem Identification

Torraco (2005) has stated that for an integrative literature review, it is important to discuss the importance of the problem and to justify why this type of methodology is the appropriate to address the problem. An integrative literature review was identified as a potential solution to the problem because the goal was to review evidence and to evaluate and critique existing empirical data, instead of summarizing findings like existing DGBL reviews (Belloti et al., 2013; Clark et al., 2015; Wu et al., 2012). In addition, most of the reviews in the area are meta-analytic or systematic in nature, but not integrative (All et al., 2014; Clark et al., 2015). Since an integrative literature review seeks to produce new knowledge, synthesize, and critique, it is recommended when a problem has been identified in the literature (Cooper, 1998).

Another factor that influenced the choice to use an integrative literature review for this study is that this type of review should be based on a framework, model, theory, or similar approach to guide the study (Cooper 1998; Torraco, 2005). In this study, Clark's (1983) framework about research on learning from media and Reeves (1995) framework about pseudoscience and the need to produce socially responsible research in instructional design and technology will be used to review and evaluate existing empirical data.

Next, the goals of the study were determined. As stated in Chapter 1, this review seeks to generate new knowledge about how the effectiveness of DGBL has been studied and identify any problems in existing empirical data. By reviewing the empirical evidence, this study evaluated if

digital learning games have any impact on instruction or if, like with other media studies, other factors such as instructional method, are the ones actually influencing learning. Finally, it was decided that this would translate into a research agenda with new directions and issues that should be addressed by researchers and teachers interested in this instructional trend, as well as a series of conceptual classifications reporting on the current state of empirical data and results from the study.

Data Collection and Evaluation

During this process, the following areas of the literature were examined: DGBL effectiveness, DGBL empirical studies, and DGBL in K-12 instruction. To conduct this literature review, academic databases, such as Education Research Complete from ERIC, Education from Jstor, and PsycINFO were browsed. These databases were selected after carefully examining other integrative literature reviews in areas related to education and curriculum and instruction (Burke & Hutchins, 2007; Echenique, 2014; Mesmer-Magnus & Viswesvaran, 2010). In addition, the researcher met with a higher education librarian who also confirmed that these three databases would yield the most results and a large sample of articles.

They key terms that were used for the search were: "DIGITAL GAME BASED-LEARNING" and "K-12" or "ELEMENTARY SCHOOL," "DIGITAL GAME-BASED LEARNING" and "MIDDLE SCHOOL," or "HIGH SCHOOL," "DIGITAL GAME-BASED LEARNING" and "EMPIRICAL" or "EFFECTIVENESS." The choice of keywords was determined after evaluating similar literature reviews (Hainey et al., 2012). Even though this integrative literature review focuses on digital learning games, the researcher is aware that sometimes studies use the term "game-based learning," so this was a consideration when evaluating studies.

The criteria used to select the studies that were reviewed and evaluated were:

1. The study was empirical
2. The study was published in a peer-reviewed publication, such as journal articles or conference proceedings in instructional design and technology or related fields
3. The study was focused on K-12 students and settings. Studies focused on teachers or not carried out in K-12 schools were excluded
4. The study was focused on the use of digital games, and not other types (e.g. physical activities, board games, analog games)
5. The study was focused on the implementation of DGBL as part of curriculum and instruction. Studies that used digital games for recreational purposes without any study of change of knowledge, attitudes, behaviors, or skills were not included

The criteria to filter studies followed the recommendations of Torraco (2005) and Whittemore and Knafl (2005) about integrating quantitative and qualitative methodologies to get a better understanding of a phenomenon or problem. Also, specifying a target population for the study (i.e. K-12 settings) allowed generalizations once conclusions were drawn from the integrative literature review. The use of specific populations has been also used in other integrative literature reviews (Hamilton, 2013; Pitt, Powis, Levett-Jones, & Hunter, 2012; Walker et al., 2013).

When browsing the databases, the researcher made sure to use filters such as "peer-reviewed article" or "conference proceeding," to comply with the search criteria of the review. In addition, the researcher used the "full-text available" filter to yield only articles whose text was fully available for review. Also, the researcher narrowed the search by filtering to fields related

to instructional design, education, learning, psychology, etc. The data collection process of this review, using the databases previously mentioned, yielded a total of 987 articles for evaluation.

In the evaluation phase, about 50% of these articles were not taken into further consideration because they were not focused on DGBL, but similar topics such as virtual reality, storytelling, digital learning tasks, adaptive learning systems, learning environments, etc. Moreover, other articles were duplicates. From the remaining articles, the researcher did not take into consideration studies that were not empirical in nature. Several articles were literature reviews, meta-analyses, systematic reviews, theoretical papers, editorial columns, and guest editorials. In addition, several articles could not be further reviewed because they focused on parents or teachers as populations. A total of 117 remained at this point for further evaluation.

From these 117 articles, several studies were not considered for further evaluation because of the following reasons: (1) they focused on teachers as the population, (2) they focused on programming, making, or designing games and not on the use of games to study effectiveness, (3) they focused on game evaluation, or (4) they were not part of the curriculum or instruction of the students. A total of 70 articles complied with all the items of the search criteria and were used to conduct the review.

` This process of establishing a sound search criteria and scope and conducting constant evaluation of the articles has been used in other studies to ensure that only relevant studies are reviewed (Flavin, 2015; Martin, Kolomitro, & Lam, 2014; Pentland et al., 2011). Finally, the researcher browsed the “Discover” database from Virginia Tech University Libraries, which is a global database that compiles all the other databases. The idea of this process was to evaluate relevant articles that were not initially identified by the databases chosen for this review. Two

articles were included after this process, yielding a final total of 72 articles that made it to the next phase of the study: data analysis.

Data Analysis

Data analysis is a very critical step in an integrative literature review. In this review, three models were adapted to determine how the data analysis took place: Whittemore and Knafl's (2005), Echenique's (2014), and Glaser's (1978) principle of constant comparison. Adapting and customizing existing models to analyze data has been identified as another particular practice in integrative literature reviews (Echenique, 2014; Tarique & Schuler, 2010). The steps that were followed in this study are: (1) determine initial codes, (2) open coding, (3) data comparison and axial coding, (4) conclusion drawing and verification, and (5) presentation of results.

Determine initial codes. Based on the problem identification and research questions, the researcher was able to determine initial codes. These initial codes were used to prepare a data collection table that was used to analyze and display data, following other integrative literature reviews (Bluestone et al., 2013; Pentland et al., 2011) and a model suggested by Russell (2005). Cooper (1998) has recommended to determine initial codes when conducting an extensive integrative literature review since it is more time-effective. The intent of the researcher was to extract relevant data from the articles and insert them into the table in each of the predetermined codes as relevant. This data collection table allowed for the visualization of themes, patterns, connections, and relationships (Whittemore & Knafl, 2005). The use of these data collection tables has allowed researchers to visually display their findings in other studies (Carlisle et al., 2010; Martin et al., 2014; Nam, Cho, & Lee, 2014; Swider, 2002).

The initial codes for this review were: (1) author(s), (2) year, (3) article name, (4) country, (5) research design, (6) instruments, (7) variables, (8) problems with measurement, (9)

outcomes, and (10) others. In addition to these initial codes, the researcher prepared a second table with the article names, authors, and year, and a column to insert data from the articles that were considered as possible influential factors in the effectiveness of K-12 DGBL. Even though "others" is not the official name of any code, category, or theme in this study, this initial label was for the researcher to pay attention to any emerging codes that were not anticipated. On the other hand, Reeve's (1995) framework of pseudoscience influenced this study and prepared the researcher with potential flaws to identify. However, the researcher let the codes, categories, and themes regarding problems in the study of effectiveness emerge naturally from the data in the articles.

Open coding. The researcher used open coding to extract relevant data from the articles and enter them into the data collection tables. Appendices B and C show the data extraction table and a coding dictionary that exemplify these open codes in an effort to guarantee research rigor, as suggested by Broome (1993). The use of these coding procedures in the form of schemes or dictionaries can increase the understanding and reliability of a review (Young et al., 2012).

Data comparison and axial coding. Once the researcher started the open coding process and data were enter into the data collection tables, an iterative process called data comparison took place. As a result of this process, the researcher identified new codes that needed to be added to the table of predetermined codes. Some of the new codes that were added include reliability of instrument, validity of instrument, sampling, length of intervention, definition of variables, description of data collection, description of data analysis, and limitations. The researcher continued entered data into the tables as open coding was taking place.

Once all 72 articles were fully analyzed through open coding, the researcher initiated axial coding, which is the next step in qualitative studies (Kendall, 1999). In this process, the

researcher was looking for common and unusual patterns, subsumed particulars into general, analyzed possible relationships, as well as the presence of any causality. After this process and still using data comparison, the researcher was able to cluster codes into categories, which are a group of codes with some similarity (Merriam & Tisdell, 2016). Continuing with axial coding and data comparison, the researcher was able to find even more commonalities and patterns in the data, which allowed for the development of themes. These themes were made up of categories that had characteristics in common. Table 11 shows quantifications of these themes to show the intensity of each one of them. This process allowed for the formation of a logical chain of evidence in the answer to research question #2 about problems in the empirical study of K-12 DGBL and to research question #3 about the influential factors. The researcher created conceptual classifications to show these logical chains of evidence as suggested by Whittemore and Knafl (2005). The researcher remained flexible, yet rigorous, throughout the process since the nature of integrative reviews asks for the researcher to keep flexibility as the study evolves (Cooper, 1998).

It is important to point out that the researcher reached data saturation, approximately half way into the conclusion of the data analysis, but continued analyzing all articles until finished. Data saturation can be defined as having a sense that there is no new information emerging from the analysis and that the analysis is producing outcomes already identified by the researcher (Merriam & Tisdell, 2016). This is important to note because it establishes that there is enough evidence of the soundness of the themes and overall findings of the study.

Conclusion drawing and verification. In this step, the researcher analyzed the data in the table and the categories and themes, paying special attention to how data were answering the main four research questions of the study and any new emerging themes. The themes were used

to verify and to ensure that conclusions are sound and consistent. In this step, possible threats to validity were verified as well.

Presentation of Results

There is a wide variety of formats for presentation of results in integrative literature reviews, including conceptual models (Alagaraja, 2014), taxonomies and matrices (Daley et al., 2010), and research agendas (Horne & Sandmann, 2012). The results of this study are presented in Chapter 4. The results are presented in text and also through a series of conceptual classifications and tables that illustrate the findings. In addition to these tables and classifications, a research agenda is presented in Chapter 4 as well.

Threats to Validity

Like any other research methodology, there are potential threats to validity when conducting an integrative literature review, which is definitely a key aspect that researchers should address (Flavin, 2015; Mesmer-Magnus & Viswesvaran, 2010). This section describes some threats to validity that this study faced and how they were addressed, as identified by Russell (2005) in an article about conducting integrative literature reviews. The goal of this is to avoid the lack of validity information in integrative literature reviews (Payne & Mullen, 2014; Schultz, 2008).

Defining Operational Definitions Too Narrowly or Broadly

To avoid this threat, the researcher established a specific search criteria, as described in the data collection section. Being aware that some terms such as “digital game-based learning” and “game-based learning” are used interchangeably, the researcher considered articles that used digital learning games, regardless of the title in the article. Similarly, the researcher considered articles with an empirical research approach, regardless of the use of that term in the study. In

these cases, there is flexibility to include a wide variety of studies, regardless of the methodology and the type of digital game, but with enough specificity that only pertinent studies would be included in the final review. The use of these specifications to avoid operational definitions that are too narrow or too broad has been identified in the literature as important (Russell, 2005; Tarique & Schuler, 2010).

Inadequate Sampling

One of the limitations in any type of literature review is not being able to include all of the relevant studies in the area for different reasons. This is a serious limitation that affects the generalizations that could be made after conclusions are drawn (Russell, 2005). To address this threat, the researcher reported on the studies that were not included and the reasons why they were not included, as established in the data evaluation section and which is recommended in integrative literature reviews (Pentland et al., 2011). Furthermore, the researcher used multiple databases, several keywords for the search, and placed no restrictions in the years of publication to ensure that a true representative sample of studies are considered for the review. The selection of databases was also discussed with a higher education librarian who confirmed that the choice of databases would yield the most results and a true representation of the literature. In addition, the researcher conducted an additional global search after coding all other articles to determine if new articles needed to be included or if there were relevant changes in the K-12 DGBL field. However, no important updates or changes were made. In addition, the researcher started to experience data saturation when 50% of the articles were analyzed, which is evidence that the sample was adequate and no relevant contradictory evidence was left out of the study.

Discrepancy between Collected Studies and Target Populations

Another challenge in the integrative literature review was the inclusion of studies that do not focus on the target population. An integrative literature review can lose validity when the studies that do not focus on the target population are included or when the specification for the population is not established. That is why it is very important to always select a specific population to conduct an integrative literature review (Torraco, 2005). To reduce this threat, this study focused only on K-12 settings and careful evaluation of this criteria was applied. Because of the variety of terms that are used to refer to K-12, the researcher paid careful attention to studies that still fit into this category, but used words such as "elementary," "middle," "primary," "high," or "secondary" education or schools. In addition, since any study was evaluated, as long as it was empirical, the researcher found a strong representative sample.

Positively Evaluating Research

According to Russell (2005) a frequent threat to validity, especially in the data evaluation stage, is to only consider or include studies that are aligned with the researcher's beliefs. Since this study looked critically at existing empirical studies to identify any problems in the study of effectiveness and any qualities of pseudoscience, this was not a potential threat. Additionally, the researcher considered a wide variety of empirical research methods with different outcomes. Analyzing contradictory evidence was a relevant part of the study as well.

Assuming Statistical Procedures, Tests, and Causality

Another issue with validity in integrative literature reviews is assuming procedures, tests, or relationships that the researcher has not reported (Russell, 2005). Similarly to the previous threat, this was not a potential threat for this study, since the goal of this study was to critically analyze empirical data about effectiveness and identify any problems and issues. Any lack of

information or inconsistencies with the way studies were conducted are reported with the goal of allowing researchers and teachers to conduct more responsible and effective research in DGBL.

Lack of Information in Reporting Results

Another threat to validity in integrative literature reviews is the lack of information when reporting results (Russell, 2005). It has been one of the major problems with this methodology, which makes it difficult to replicate studies or understand how conclusions were drawn or how important steps were taken (Baldwin, Mills, Birks, & Budden, 2014; Nogueira et al., , 2013). In an integrative literature review it is necessary to describe with detail how data were collected, evaluated, and analyzed, and how it all connects to the conclusions in the study. This chapter has focused on avoiding this threat by explaining in detail how the study was conducted.

Reflexivity

Reflexivity can be defined as "the continuous process of self-reflection that researchers engage in to generate awareness about their actions, feelings and perceptions" (Darawsheh. 2014, p.561). Including reflexivity into a qualitative study ensures rigour, transparency, reliability, and validity. In order to avoid bias and subjectivity in this study, the researcher went through a reflexivity process that will be described in the next sections.

The researcher's interest in DGBL started as part of a research assistantship, where the design and adoption of digital learning games in middle schools was the main task. In this role, the researcher had to provide feedback on the instructional soundness of the games, as well as collect and analyze data. The researcher contributed to the publication of journal articles and presented at conferences these findings, in collaboration with other members of the research team. During this process, the researcher's curiosity in K-12 populations also increased and

influenced the inclusion of these types of learners in the research agenda. Similarly, the researcher identified the need to study at a deeper level, the effectiveness of DGBL.

Years later, the researcher was appointed as an instructional designer, and later instructional design manager in a higher education institution. As part of this role, the researcher trained faculty on the design and implementation of digital learning games and led four communities of practice on DGBL. Because of these experiences, the researcher identified the need to investigate the study of effectiveness of DGBL, as well as problems found in the empirical literature. In addition, the researcher identified the need to study the extent to which a digital game played a role in enhancement of learning and if there were other elements that also impacted learning. By investigating all of this, the findings of this dissertation would inform the researcher's practice and would allow the researcher to base decisions, training, and overall work on valid empirical findings. As previously mentioned, the researcher's main interest in finding the current state of K-12 DGBL has contributed to a high level of transparency and objectivity. The researcher has remained flexible, exploratory, and critical and has no interest or need to find a specific type of information in favor or against the effectiveness of K-12 DGBL.

CHAPTER 4

RESULTS

This chapter presents the results of this integrative literature review. A total of 72 peer-reviewed articles were analyzed for the study, using the evaluation criteria explained in Chapter 3. Appendix A shows all the studies that were included in the review.

Research Question #1

The first research question of this study *"How is the effectiveness of DGBL in K-12 being studied in empirical literature, including research designs, instruments, variables, and outcomes?"* focuses on exploring the current status of K-12 DGBL empirical research. All the calculations are based on the peer-reviewed journal articles (n=72) that were selected for this study.

Countries.

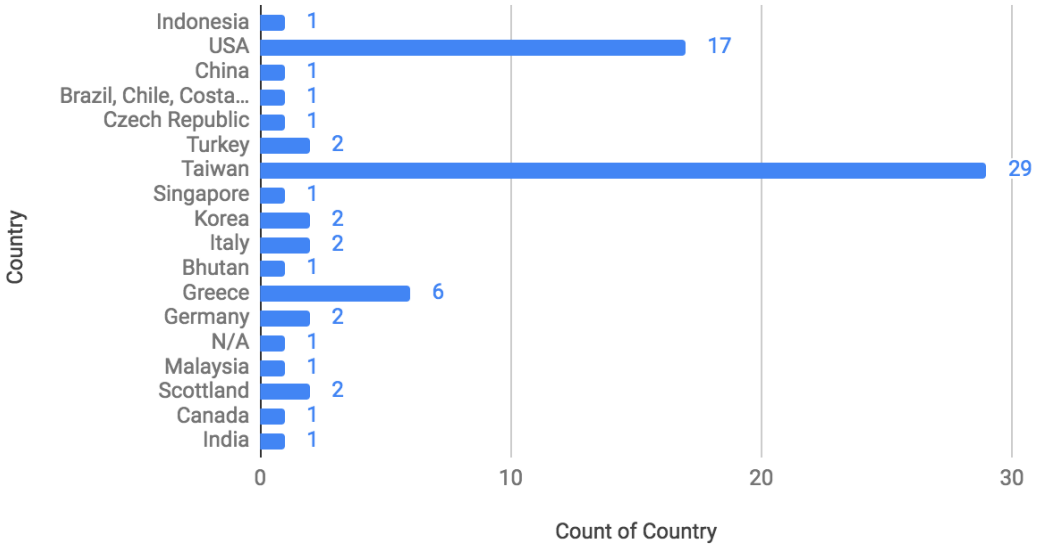

Figure 2. Classification of countries for K-12 DGBL studies.

According to data from this study, DGBL and its effectiveness in K-12 classrooms has mostly been studied in Taiwan (40%). In the second and third place are the United States (24%),

and Greece (8%) respectively. Figure 2 shows the rest of the countries where these studies have been conducted. These data shows that most studies are conducted in Asia and North America, while very few are conducted in Latin America. Moreover, no studies from Africa were found for this review.

Subject Matter. Several subject matters have been used as a platform to implement DGBL in K-12 classrooms. Figure 3 shows a distribution of these subject matters.

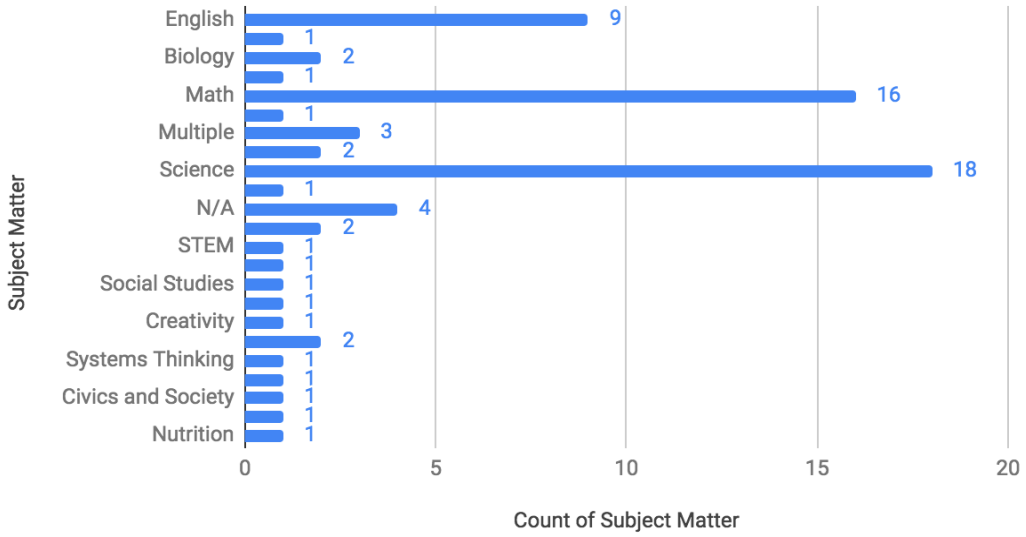

Figure 3. Distribution of K-12 DGBL studies by subject matter.

Most of the studies of this review focused on the STEM fields (Science, Technology, Engineering, and Math) with the 57%, while languages comprised 13%. Very uncommon was the study of DGBL for subject matters like creativity or systems thinking with 1.2% each.

Type of games. The results of this integrative literature review show that many types of games, not only those exclusively designed for learning, have been used to implement DGBL in K-12 classrooms. From the studies that had detailed information about their games, approximately 12% of the games were commercially available or available online. Also, 20% of the games were multiplayer or collaborative in nature. Other games that were found in these

study include web-based games (Li et al., 2013) and educational games (Cheng, Lin, She, & Kuo, 2017).

Knowledge domain. All three knowledge domains (cognitive, affective, and psychomotor) were found in these studies. In many instances, more than one knowledge domain were studied in one single article. The most frequent domains that were studied were the cognitive (79%) and affective domains (75%). Only three articles (4%) focused on the psychomotor domain. Table 4 shows examples of studies conducted for each knowledge domain.

Table 4

Knowledge domains found in K-12 DGBL literature.

Knowledge Domain	Examples of Variables Studied	Authors
Cognitive	content knowledge, performance, learning achievement, understanding of content, learning, academic achievement	Adisti, 2016; Chen & Lee, 2018; Chen, Liu, & Shou, 2018; Denham, 2015; Miller, Robertson, Hudson, & Shimi, 2012; Yang, 2015
Affective	engagement, acceptance of DGBL, attitudes towards subject matter, attitudes towards learning, enjoyment perception	Annetta et al, 2009; Cheng, et al., 2013; Choi, 2014; Costu, Aidin, & Filiz, 2009; Tsai, 2016
Psychomotor	manual skills, motor skills, use of tool (software)	Hsiao, Chang, Lin, & Hu, 2014; Hsiao & Chen, 2016; Simpson & Clem, 2008

Size and characteristics of the populations. The study with the smallest population size had 9 participants, whereas the study with the largest population had 892 participants. The median of these populations is 68.5 and the mode is 53.

In terms of characteristics of the population, since this review focused on K-12 classrooms, participants were expected to be children and teenagers. Some studies disclosed

specifics about the grade or age, or both. Since studies reported different characteristic for the population, it was not possible to make a numeric generalization for all of them. Only one study (n=1) focused on learners with special needs with claims that DGBL was effective (Ke & Abras, 2013).

Research Designs and Methodologies. The most common research design found in this examination of empirical K-12 DGBL studies was the experimental design with 40% of the studies. In the second place, it was found that the quasi-experimental design was found in 30% of the studies, while the case study was used in 15% of the studies. Other research designs that were used in these studies were research and development (Adisti, 2016), survey methodology (Canyaka & Karamete, 2009), and the exploratory design (Lucht & Heidig, 2013) with 1% each. One study (n=1) based the experiment on design-based research (Anderson & Barnett, 2013).

Mixed methods was the most prevalent methodology with 47% of the studies using it. Very close was the quantitative methodology with a 45% of the studies. Qualitative methodologies were only found approximately 7% of the studies. Table 5 presents a classification of studies by research design and methodology.

Table 5

Classification of research designs and methodologies in K-12 DGBL studies.

Research Design	**Methodology**	**Authors**
Experimental	Quantitative	Dorji, Panjaburee, & Srisawasdi, 2015; Eseryel, et al.,, 2014; Hawlitschek & Köppen, 2014; Ku, Chen, Wu, Lao, & Chan, 2014.
Experimental	Mixed methods	Chen, Wang, Lin, 2015; Huang et al., 2014; Kebritchi, Hirumi, & Bai, 2010; Mavridis et al., 2017; Papastergiou, 2009.
Quasi experimental	Quantitative	Bunch, Robinson, Edwards, & Antonenko, 2014; Chang, Wu, Weng, Sung, 2012; Cheng et al., 2017; Hsiao & Chen,

		2016; Hwang, Yang, & Wang, 2013; Yien, Hung, Hwang, & Lin, 2011
Quasi experimental	Mixed methods	Hsiao, Chang, Lin, Chang, & Chen, 2014; Hung, Huang, & Hwang, 2014; Hwang, Chiu, & Chen, 2015; Hwang, Hsu, Lai, & Hsueh, 2017; Sung, Hwang, & Yen, 2015
Case study	Qualitative	Costu et al., 2009; Simpson & Clem, 2008; Warren, Dondlinger, Stein, & Barab, 2009
Case study	Mixed methods	Brom et al., 2010; Dourda, Bratitsis, Griva, & Papadoloupou, 2014; Ke & Abras, 2013; Petros & Georgios, 2011; Shah & Foster, 2014

Instruments. In the K-12 DGBL empirical literature, several research instruments were identified. The most common type of instrument was the pre/post-test, which was used in approximately 65% of the studies. In approximately 10% of the studies, researchers only used a post-test to measure effectiveness. However, many studies did not provide specific information about the instruments, including pre/post-tests, as it will be reported later in this chapter. The authors who provided specifics about these pre/posts tests, reported a variety of formats, including open-ended questions (Chen et al., 2015), single choice questions (Hung, Kuo, Sun, & Yu, 2014), and multiple choice (Chen & Lee, 2018).

Other common types of instruments that have been used to measure effectiveness in these studies have been questionnaires, surveys, or scales (55%). From these studies, approximately 10% had a pre/post-survey format. In addition, researchers have used interviews (30%) and observations (31%). In order to carry out observations, the researchers also used field notes (Anyaegbu, Ruphina, Ting, Wei, & Li., 2012), video recordings (Dourda et al., 2014), and field notes (Brom et al., 2010).

On the other hand, only approximately 5% of the studies used data from the game, such as performance logs, to measure effectiveness of K-12 DGBL. Other instruments that were

present in few studies include evaluation tasks (Dourda et al., 2014), log-files (DiCerbo, 2014; Lucht & Heidig, 2013), teaching artifacts (Miller et al., 2012), worksheets (Panoutsopoulos & Sampson, 2012), and journals (Simpson & Clem, 2008).

In some instances, well-known research instruments were used to study variables of interest. The Protocol for Classroom Observations was used to study engagement (Annetta et al., 2009), whereas the Motivated Strategies for Learning Questionnaire (Chen, et al., 2015) and the Survey of Motivation in Chemistry Education (Chen, Wong & Wang, 2014) were used to study motivation. Hsiao and Chen (2016) used a variety of instruments to study the effects of digital games in the psychomotor domain: the Gross Motor Performance Measure, the Comprehensive Developmental Inventory for Infants and Toddlers, the Peabody Developmental Motor Scales II, the Preschooler Gross Motor Quality Scale, and the Fundamental Motor Ability Tool. Other well-known instruments are the Logivali Test (DiCerbo, 2014), the Creativity Assessment Packet (Hsiao, Chang, Lin, & Hu, 2014), the Mathematics Anxiety Rating Scale (Huang et al., 2014), and the Index of Learning Styles (Hwang et al., 2015). Table 6 presents a classification of instruments that have been used to study K-12 DGBL effectiveness.

Table 6

Instruments used to measure K-12 DGBL effectiveness.

Instrument	**Authors**
Pre/post test	Adisti, 2016; Chang et al., 2012; Chen & Lee, 2018; Cheng et al., 2017; Denham, 2015; Eseryel, Ge, Ifenthaler, & Law, 2011.
Questionnaires, scales, or surveys	Chen, et al. 2015; Dagnino, Ballauri, Benigno, Caponetto, & Pesenti, 2013; Hawlitschek & Köppen, 2014; Huang et al., 2014; Hung, Huang, & Hwang, 2014; Hwang et al., 2017; Ku et al., 2014; Razak & Connolly, 2013.

Interviews	Anderson & Barnett, 2013; Brom et al., 2010; Cheng, et al., 2013; Costu et al., 2009; Kebritchi et al., 2010; Miller et al., 2012; Razak & Connolly, 2013.
Observations	Anyaegbu et al., 2012; Beserra, Nussbaum, Zeni, Rodriguez, & Wurman, 2014; Hsiao, Chang, Lin, et al., 2014; Mat Zin & Masrop, 2010; Muehrer, Jenson, Friedberg, & Husain, 2012; Ott & Pozzi, 2012; Schaaf, 2012; Young & Wang, 2014.
Data from the game	Beserra et al., 2014; Di Cerbo, 2014; Lucht & Heidig, 2013.

Dependent Variables and Outcomes.

In terms of the dependent variables that were studied to determine if DGBL was effective, mastery of the subject matter or content was the most prevalent theme with approximately 60% of the studies. The way researchers labeled this variable was very diverse, with some of the terms including: content knowledge (Adisti, 2016), learning (Chen et al., 2015), performance (Hawlitschek & Köppen, 2014), school achievement (Dagnino et al., 2013; Hwang et al., 2017), and effectiveness (Mavridis et al., 2017).

Approximately 20% of these studies used digital games to measure learner's attitudes towards a wide variety of factors, such as the subject matter (Cankaya & Karamete, 2009), learning (Choi, 2014), and games (Razak & Connolly, 2013). On the other hand, approximately 10% of the studies used engagement as a dependent variable, while motivation was found in approximately in 27% of the studies. The study of 21st century skills as dependent variables was found in approximately 10% of the articles. This includes problem-solving (Eseryet et al., 2011), task persistence (DiCerbo, 2014), and logical reasoning (Dagnino et al., 2013). A complete list of dependent variables identified in these empirical studies can be found in Appendix B.

It is important to note that in some studies independent variables not related to the game were analyzed. In one study (n=1), results indicated that prior knowledge, network speed, and

motivation for learning played a role in effectiveness (Suh et al., 2010), which can indicate that in addition to the game, these factors could have impacted the overall learning experience. However, in other studies, independent variables did not impact effectiveness. For instance, gender was not found to have an impact on content knowledge, attitudes, or motivation (Cheng et al., 2013; Muehrer et al., 2012; Yien et al., 2011). Similarly, in one study (n=1), prior knowledge, computer skills, and English language skills did not have a significant impact on achievement and motivation of learners (Kebritchi et al., 2010).

In terms of outcomes of these K-12 DGBL studies, approximately 93% of the studies claimed that DGBL was effective to enhance learning. However, in this 93%, there were some articles that only reported effectiveness in some of the variables being studied and not in all of them. These reports of partial effectiveness make up 16% of the studies included in this review. Appendix B provides a table with outcomes for all of these empirical studies.

Summary of Research Question #1. Results from this integrative literature review has shown that most of the studies have taken place in Taiwan and the United States. No studies were found in Africa, while some studies were in found in Europe, specifically in Greece. In addition, most of the studies focused on STEM (Science, Technology, Engineering, and Math) courses to measure the effectiveness in DGBL in K-12 classrooms. The cognitive and affective domains were found in most of the studies and little empirical research has been conducted focusing on the psychomotor domain.

The population size for these studies varied from 9 to 892 participants, with a median value of 68.5 and a mode value of 53. Since studies included in this integrative literature review focused on K-12 classrooms, the population for these studies were children and teenagers. Given

that some studies disclosed the grades and not the age of participants, it is not possible to provide accurate median and mode for these populations in terms of age.

The experimental research design has a very strong use in K-12 DGBL studies, with quasi-experimental designs also appearing frequently. Other research designs, such as research and development, survey methodology, and exploratory design, were rarely found. In terms of methodologies, the most prevalent was the mixed-methods methodology, with the quantitative one in a second place. Much less frequent was the use of qualitative studies, which were mostly found through case studies.

The empirical studies used in this integrative review mainly used pre/post-tests in a wide variety of formats (e.g. multiple choice, single choice, open ended). The second most frequently used instrument was surveys, which sometimes were referred to as scales or questionnaires, in these studies. Other instruments used in these studies include observation instruments and data from the game. Many researchers have used well-known instruments, while others have developed their own.

In the study of effectiveness, content knowledge or understanding of subject matter has been the main focus, with attitudes also being studied. Engagement and motivation towards the subject matter or use of games were also part of the findings of this study. Almost all of the studies reported in this review made claims about effectiveness when it comes to DGBL implementation. However, very few articles studied or saw external factors to the game as responsible for effectiveness.

This research question was able to answer what DGBL effectiveness has meant for different researchers and how they have attempted to measure it, as well as the instruments, research designs, and variables they used in the process. This research question also answered

how many studies have also been able to demonstrate that DGBL is an effective learning strategy.

Research Question #2

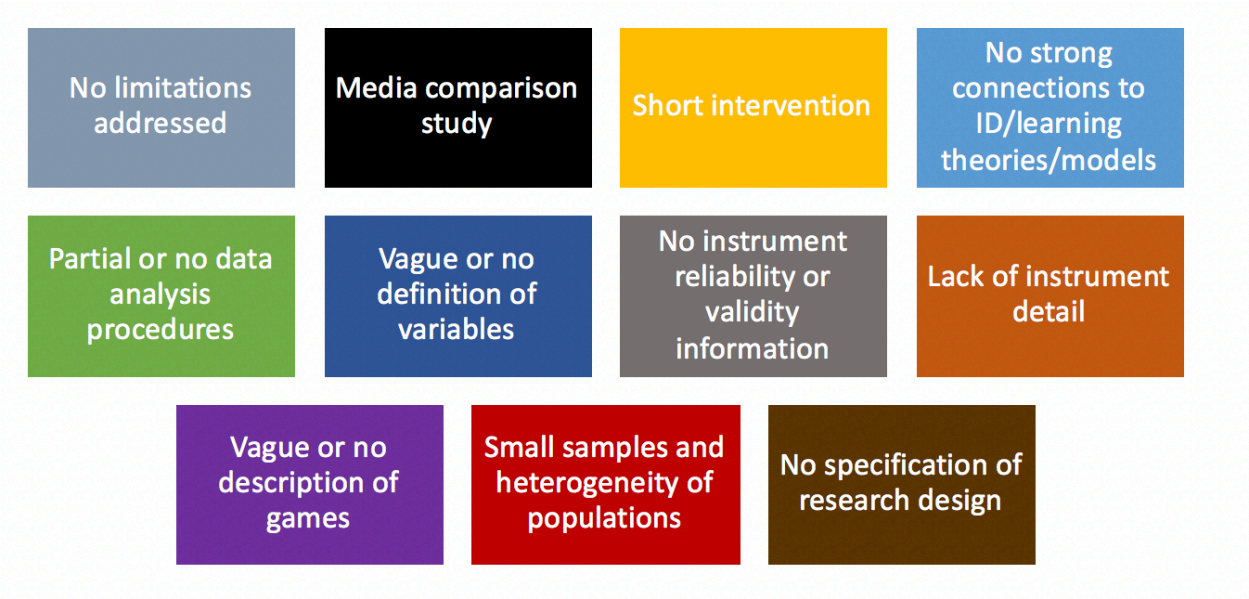

Figure 4. Problems found in K-12 DGBL Empirical Literature

The second research question of this study, *"What problems are found in the literature regarding the study of effectiveness in K- 12 DGBL?,"* was designed to identify issues and flaws when studying the effectiveness of K-12 DGBL. The goal of this research question is to evaluate and critique current empirical literature in an attempt to find if claims about effectiveness are made despite flaws in the research process. The themes that were found in the K=-12 DGBL literature for these questions are: (1) no limitations addressed, (2) media comparison, (3) short interventions, (4) no strong connections to instructional design/learning theories or models, (5) partial or no description of data analysis procedures, (6) vague or no definition of variables, (7) no instrument reliability or validity information, (8) lack of instruments details, (9) vague or no descriptions of games, (10) small samples and heterogeneity of populations, and (11) no

specification of research design. Figure 4 shows a conceptual classification of these problems found in the K-12 DGBL literature.

No limitations addressed. Directly addressing limitations is important because it is part of the rigor and transparency of a study. Approximately 50% of the studies in this review did not directly address limitations that could help researchers fully understand the scope of results and challenges in data collection and analysis, as well as to replicate the study. However, the researcher identified instances in which the study directly acknowledged and addressed its limitations. In some instances, authors acknowledged that results could not be generalized (Beserra et al., 2014; Bunch et al., 2014; Chen & Lee, 2018). This lack of generalizations were due to small samples (Dagnino et al., 2013), short interventions (Hwang et al., 2017), or having a game that was too specific (Chen & Lee, 2018). In other instance, limitations that were reported in these studies were lack of data (Ke & Abras, 2013) or participants withdrawing from the study (Bunch et al., 2012). Table 7 shows the types of limitations that authors addressed in these studies.

Table 7

Examples of limitations directly addressed by authors.

Type of limitation	**Authors directly addressing it**
Small samples	Beserra et al., 2014; Dagnino et al., 2013; Hwang, Wu, & Chen, 2012; Hwang et al., 2017; Ke & Abras, 2013; Ku et al., 2014; Miller et al., 2012
Short intervention	Chen, Liao, Cheng, & Chan, 2012; Chen et al., 2014; Denham, 2015; Hsiao & Chen, 2016; Hsiao, Chang, Lin, & Hu, 2014; Hsiao, Chan, Lin, Chang, & Chen, 2014; Hwang, Wu, & Chen, 2012; Hwang et al., 2017; Panoutsopoulos & Sampson, 2010; Papastergiou, 2009

Need to examine validity/reliability of instruments	Anderson & Barnett, 2013; Chen et al., 2012; Denham, 2015; DiCerbo, 2014; Hsiao, Chang, Lin et al, 2014; Mavridis et al., 2017
No applicability to other settings/types of game	Chen & Lee, 2018; Chu & Chang, 2014; Hung, Huang, & Hwang, 2014; Hwang et al., 2013; Schifter et al., 2012
Incomplete data sets	Bunch et al., 2012
Not use of random selection	Beserra et al., 2014; Miller et al., 2012
Acknowledging other factors could have impacted results	Eseryel et al., 2014; Hwang, Wu, & Chen, 2012; Hwang et al., 2017; Ku et al., 2014; Mavridis et al., 2017

Even though several researchers did not directly addressed the limitations of their studies, the researcher analyzed the content of the articles to identify problems and limitations. Those are discussed in the next sections.

Media comparison. The most common problem found in the empirical K-12 DGBL literature was the presence of media comparison studies. Approximately 54% of the studies reviewed had the problem of media comparison. As Clark (1983) has established, it is not instructionally sound to compare two or more different media. Even though many studies have shown no significant difference among media and that in many instances there is a misinterpretation between media and instructional method (Warnick & Burbules, 2007), media comparison studies are still frequent in the K-12 DGBL literature.

In the studies analyzed in this review, researchers compared digital games to paper and pencil activities (Beserra et al., 2014), lecture and discussion (Bunch et al., 2014), textbooks (Choi, 2014; Dorji et al., 2015), conventional elearning (Chu & Chang, 2014), facilitation (Eseryel et al., 2011), physical games (Hsiao & Chen, 2016), video-based learning (Lin et al., 2013), text and photo viewer (Petros & Georgios, 2011), ebooks (Sung et al., 2015), drill and

practice (Young & Wang, 2014), and conventional or traditional instruction (Singaravelu, 2008; Mavridis et al., 2017).

Short interventions. Having short interventions is a frequent problem in the instructional design and technology literature and it is one of the characteristics of pseudoscience that Reeves has addressed in his work (1993, 1995). The adjective "short" can be subjective and not identified as a problem in a study by some researchers, even though some have found that their interventions of a day, a couple of days, or even weeks are short (Chen et al., 2012; Chen et al., 2014; Denham, 2015; Hsiao & Chen, 2016; Hsiao, Chang, Lin, & Hu, 2014). It was difficult to calculate statistical information (i.e. mean or median) because some studies provided their length in days, while others in weeks. In other instances, there was no clear information about the actual length of the intervention.

Approximately 33% of these studies had short interventions, ranging from 1 to 10 days. Those studies that had a longer duration had an average value of 11 weeks. Longer interventions of 1 year (Eseryel et al., 2014) and 3 years (Ott & Pozzi, 2012) were found only twice in this review (n=2). Having short interventions is a problem in the study of effectiveness because it is difficult to see patterns of change over time if the intervention just took one day or a few days. Some researchers have acknowledge that it take more than a semester to fully master some skills (Yang, 2012), which is another reason why short interventions are not always effective for learning enhancement.

No strong connections to ID/learning theory. Even though DGBL is an instructional strategy, approximately 42% of the studies in this review did not have strong connections to instructional design or learning theories or models to guide the study or the design of the games.

Table 8 shows examples of instructional design and/or learning theories/framework used in these studies.

Table 8

Examples of instructional design/learning theories found in studies.

Instructional Design/Learning Theory/Framework	**Examples of Authors**
Constructivism/cognitivism	Chen et al., 2018; Dagnino et al., 2013; Eseryel et al., 2014; Hsiao et al, 2014; Hwang et al., 2013
5E Instructional Model	Chen et al., 2014; Dorji et al., 2015
Technology Acceptance Model	Cheng et al., 2013
Content & Language Integrated Learning	Dourda et al, 2014;
Problem-solving	Eseryel et al., 2011; Hwang et al., 2017; Panoutsopoulos & Sampson, 2010; Panoutsopoulos & Sampson, 2012; Simpson & Clem, 2008
Self-determination/Self-efficacy theory	Eseryet et al., 2014
Learning style theory	Hwang, Sung, Hung, Huang, & Tsai, 2012
Experiential learning	Kebritchi et al., 2010
ADDIE	Mavridis et al., 2017

Partial or no description of data analysis procedures. Approximately 20% of the studies analyzed in this review did not provide data analysis procedures or the data analysis procedures were vague, making it not possible to fully understand the steps that the researcher used to come up with results. In some instances, the mixed methods studies had thorough and clear data analysis procedures for the quantitative portions, but not for the qualitative sections. One of the goals of research in general is to add new contributions to a field and for researchers

to build upon existing knowledge, so not having these specifications in the data analysis procedures is a problem that needs to be addressed and avoided in future K-12 studies.

Vague or no definition of variables. In this review, approximately 75% of the studies did not define all of the variables that were going to be analyzed. Even though some variables are easy to interpret and contextualize, like gender and age, there are some variables such as effectiveness or knowledge that need to be put into context and defined to fully understand the scope of the study and the items that the researcher is going to focus on. Even in the studies that defined the variables to be studied, most researchers only defined or put into context some of the variables to be studied, but not all of them. Also, it is important to note that researchers might use a term in different ways. For instance, this integrative review found that for some researchers DGBL effectiveness is connected to improvement in achievement (Yien, et al., 2011), whereas for others it is about the changes in perceptions in attitudes (Razak & Connolly, 2013). This is the reason why the definition of variables and their contextualization is an absolute need in research. Table 9 provides instances of authors that defined their variables and placed them into context.

Table 9

Examples of definition of variables in these studies.

Variable	Definition	Author
Creativity	"a set of abilities, skills, motivations, and states that that are inextricably linked to deal with problems"	Hsiao, Chang, Lin, & Hu, 2014, p.377
Mastery learning	"different students require different durations of study to attain the same degree of mastery"	Lin et al., 2013, p. 273
Flow	"flow occurs when people fully engage in a task with personal satisfaction"	Chang et al., 2012, p. 776
Task persistence	"Task persistence is defined as continuing with a task despite obstacles or difficulty."	DiCerbo, 2014, p. 18

Motor skills	"Motor skills involve the knowledge of how to complete a task and when to conduct the task in order to achieve its completion…"	Hsiao & Chen, 2016, p. 153

No reliability or validity information of instruments. In research, reliability and validity of instruments is very important. Reliability can be defined as the consistency that an instrument has to produce the same results every time it is used, whereas validity is ensuring that an instrument measures what it is actually supposed to measure (Kimberlin & Winterstein, 2008).

Approximately, 31% of the studies of this review did not have information about the reliability of the instruments. Similarly, approximately 14% of the studies did not report reliability for all the instruments used in the study, but just for some of them. In those instances, usually the knowledge tests do not have information about the reliability. In the case of validity, approximately 53% of the studies do not have information about the validity of the instruments, whereas 11% of the studies did not report validity for all of the instruments, but only for some of the ones that were used.

Lack of details about instruments. As previously mentioned, several K-12 DGBL studies have used well-known and easy-to-access instruments to conduct the studies (Bunch et al., 2014; Cheng et al., 2017). However, in many studies, researchers and teachers have created their own instruments for these interventions. In those instances, it is important to have as much detail as possible about the instruments, so other teachers can easily replicate the study. This is also beneficial for readers and researchers to know what was exactly measured and how it was measured.

One problem that this review found was the lack of details for the research instruments. Approximately 70% of the studies did not have specific details about the instruments that were

used in the studies. On the other hand, approximately 42% of the studies had partial vague information about the instruments or had just details for some of the instruments in the study.

Small Samples and Heterogeneity in Populations. Reeves (1993, 1995) has stated in his framework that small and inadequate samples are a problem of research in instructional design and technology. In this study, the mean number of participants is 68.5 and the mode is 53. Even though the adjective "small" can be subjective to define a population, these statistical values make it difficult to make broader generalizations to larger populations.

In addition, approximately 33% of the studies reported ranges in grades or ages of the populations that were analyzed in one single study. This heterogeneity in samples could be problematic because there could be differences in the background, characteristics, knowledge, or experiences of each subgroup. The researcher should be able to isolate those possible influential factor, but it is difficult with these heterogeneity in populations.

No specification of research design. Although not too common, with approximately 8% of the studies, some studies did not specify the type of research design that was used to conduct the study. In these instances, authors used the term "study" without more details about the study. Even though in some cases, more experienced researchers can infer the research design that was used, it can be problematic for junior researchers or readers or practitioners not too familiar with research designs to make these inferences. This is specially important for purposes of study replications.

Vague or no descriptions of games. Approximately 25% of the studies in this integrative review did not provide thorough information about the game and/or characteristics of the games that were used in the interventions. Providing this information can be beneficial for teachers, since they could be able to identify the characteristics and elements that they should

look for in a game when implementing. In addition, reporting about the game can help researchers identify relationships between games and outcomes.

Summary of Research Question #2. In the 72 peer-reviewed articles that were included in this integrative review, the following problems were identified by the researcher: (1) no limitations addressed, (2) media comparison, (3) short interventions, (4) no strong connections to instructional design/learning theories or models, (5) partial or no description of data analysis procedures, (6) vague or no definition of variables, (7) no instrument reliability or validity information, (8) lack of instruments details, (9) vague or no descriptions of games, (10) small samples and heterogeneity of populations, and (11) no specification of research design. Several of these problems are aligned with Reeve's (1993, 1995) pseudoscience framework, such as the lack of connections to theories, short interventions, vague definition of variables, and small samples. Even though the author of this review concluded these were problems in the studies that were reviewed, other researchers might not necessarily perceive them as problems and find the decisions and procedures in these empirical studies sound. Table 10 lists these problems and an example study of where they were found.

Table 10

Examples of problems in K-12 DGBL empirical literature.

Problem in K-12 DGBL Empirical Literature	**Examples of Studies**
No addressing of limitations	Adisti, 2016
Media comparison	Chang et al., 2012
Short interventions	Costu et al., 2009
No strong connections to ID/learning theory/model	Cheng et al., 2017
Partial or no description of data analysis procedures	Muehrer et al., 2012
Vague or no definition of variables	Bunch et al., 2014

No instrument reliability or validity information	Ku et al., 2014
Lack of details about instruments	Anderson & Barnett, 2013
Small samples and heterogeneity of populations	Costu et al., 2009
No specification of research design	DiCerbo, 2014
Vague or no descriptions of games	Cankaya & Karamete, 2009

Finally, this research question was able to answer what common problems or flaws have been found in existing empirical K-12 DGBL literature, with the goal of allowing researchers to interpret the findings and make informed decisions when designing their studies.

Research Question #3

The third research question of this study, *"What factors or conditions might be influencing the effectiveness of K-12 DGBL in these empirical studies?,"* focuses on those elements that could have resulted in an effective experience for the learners. Sixty-seven (n=67) articles were included in the analysis for this question, given that the researcher wanted to focus on those studies that had claims of learning effectiveness through digital games. As Clark (1983) has stated, studies sometimes claim that technologies enhanced learning and were effective for learners, but that it is not necessarily because of the technology, but because of certain factors or conditions that could have influenced this learning. For this research question data were analyzed to find elements related and non-related to the technology to identify those that could have been influential in learning. One of the goals of this question is to identify if there are unique elements or characteristics in learning games that are not found in other media. As Clark (1983) stated, finding these unique attributes could make the case for media influencing learning.

Five themes emerged from the data analysis of the peer-reviewed journal articles. These themes, from most prevalent to less prevalent are: (1) interactive elements of games, (2)

application of instructional design principles, (3) active learning, (4) learner's characteristics and attitudes, and (5) teacher's role. The following sections will describe in detail possible influential factors in the effectiveness of DGBL. Figure 5 shows a conceptualization of the five themes that were identified in this study as possible influential factors in K-12 DGBL effectiveness,. In addition, Table 11 presents the categories for each one of these themes.

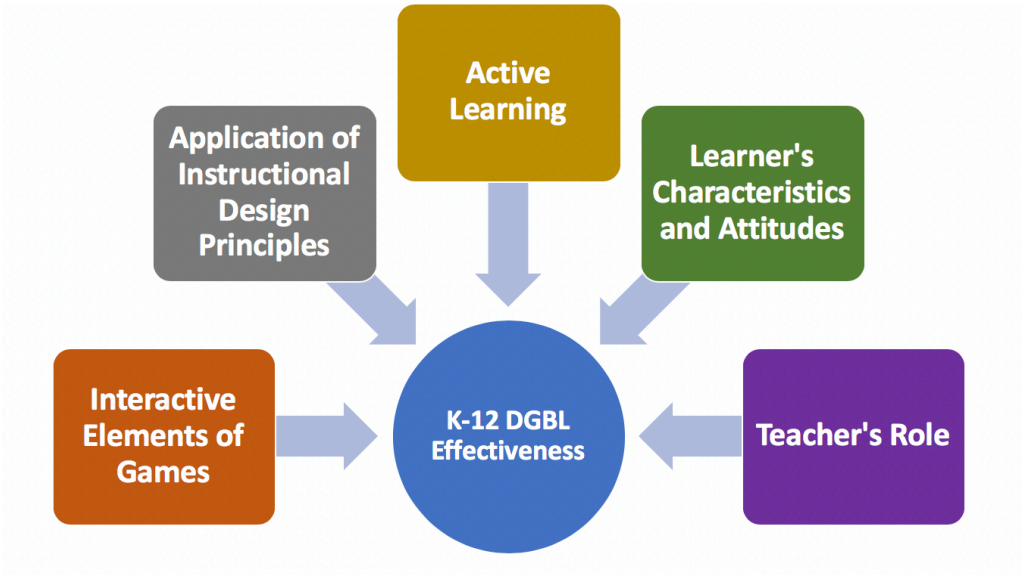

Figure 5. Possible influential factors in K-12 DGBL.

Interactive elements of games. The most prevalent theme in this study, in terms of possible influential factors or conditions, was game elements and characteristics. There are elements in games that are not exclusive to this particular type of learning technology, such as feedback and rewards, that sometimes enhance and make more effective the learning experience.

Feedback and Rewards. In this study, it was shown that games have the ability to provide different types of feedback to learners, especially immediate feedback (Hsiao, Chang, Lin, & Hu, 2014). Other types of feedback that are present in games are explanatory (Papastergiou, 2009), positive (Young & Wang, 2014), negative (Schifter et al., 2012; Tsai,

2016), and contextual (Chen et al., 2015). In addition, games offer different representations of feedback such as visual feedback (Ke & Abras, 2013) or audio feedback (Lucht & Heidig, 2013).

Similarly, rewards can be considered one of the most traditional types of feedback in games (Hwang et al., 2015). In most of the studies included in this review, learners had the opportunity to get all of these types of feedback, which could have definitely helped them clarify misconceptions and reinforce behaviors.

Goals and rules. A fundamental part of any game is a clear and specific goal (Kebritchi et al., 2010). The pursuit of a game goal, which can translate into a more active approach from the learner, could have a strong relationship with effectiveness in these empirical studies. Usually a goal is embedded in the narrative of the game, providing a stealth learning experience to the student as they pursue it (Choi, 2014; Hwang, Sung, Hung, Huang, & Tsai, 2012). These goals can also take the form of a mission, in which the learner has to apply prior knowledge, inquire, collaborate, and solve problems to accomplish a task (Chu & Chang, 2014; Kebritchi et al., 2010). Similarly, a goal can have an intense and arduous nature, encouraging the learner to apply knowledge as they search for something. This type of game goal is known as quest and was found in studies of this review. For instance, in some studies, quests have been connected to social commitment and persistence in the learning process (Chen et al., 2012; DiCerbo, 2014).

It is important to point out that in these studies clear rules were connected to the goals of these games (Cheng et al., 2017; Hwang et al., 2017). As evidence from these studies show, these rules contributed to the excitement and fairness of playtime (Mavridis et al., 2017).

Challenges. Another key element found in games is the presence of challenges (Hsiao, Chang, Lin, & Hu, 2014). Challenges might have played a relevant role in the effectiveness of these DGBL empirical studies because of the motivation it triggers in learners to overcome them

to get a reward (Hsiao, Chang, Lin, & Hu, 2014). In some instances, learners have been motivated not only to overcome the challenges, but to test their knowledge and abilities through these challenges and to even challenge their classmates (Cheng et al., 2013). One important aspect of these challenges in digital games was their strong connections with the subject matter, which allowed the learners to directly apply knowledge from the class (Mavridis et al., 2017; Sung & Hwang, 2013). In other studies, challenges are embedded in a storyline, creating a stealth application of knowledge (Hwang et al., 2017), while in others the challenge was timed to ensure learners had a specific amount of time to display mastery (Ke & Abras, 2013).

Another type of challenge that can be found in games is the open-ended one, which allows learners to try different possibilities (Ke & Abras, 2013). This type of challenge in games can be beneficial for problems or questions that have more than one solution. On the other hand, in one study, not having peer pressure while playing the game allowed learners to focus on overcoming the challenge (Chen et al., 2018). In another study, researchers reported that challenges in the game were moderate, which made the experience effective and positive (Young & Wang, 2014). In this study, participants stated that even though the game was challenging, they were still motivated to continue playing because it was fun or interesting.

Narrative, Scenarios, and Characters. A relevant affordance of digital games is the use of narrative to engage learners. In the empirical studies of this integrative review, the use of narrative was a prevalent category to embed subject matter into a story that is engaging to students and that can simplify and concretize complex topics (Warren et al., 2009). DGBL studies have also used narrative to promote intrinsic motivation in learners and to encourage them to persist through the game (Dourda et al., 2014).

Scenarios can also be an effective element of games to enhance learning. A frequent category in this study was the use of real-life scenarios in the narrative of the games (Brom, et al., 2010). The use of these real-life scenarios was effective for learning because students were immersed in daily situations, allowing them to perform and apply knowledge that they had previously acquired in the classroom (Annetta et al., 2009; Hwang et al., 2015). The use of game scenarios can also motivate learners because they can visualize their future, explore professional opportunities, make decisions, or vicariously live adventures in a safe space (Hwang et al., 2015; Shah & Foster, 2014; Sung, Hwang, & Yen, 2015; Yang, 2012).

As a less frequent category, there were fantasy scenarios as part of the game design to engage learners and enhance their learning (Liu, Rosenblum, Horton, & Kang, 2014). Even though these games had fantasy scenarios, there were still strongly connected to the subject matter, which still contributed to the learning of the students (Chu & Chang, 2014).

Another aspect of these games that played a role was the use of characters or avatars. Learners can relate to characters and avatars and they can also visualize characteristics or traits on a specific time or situation through them (Cheng, Lin, She, 2015). In other instances, characters and avatars can give a sense of guidance and companionship, which is not present in many digital and asynchronous environments (Hsiao, Chang, Lin, & Hu, 2014). Furthermore, learners have sometimes felt more relaxed and at ease when working and receiving instructions from a character or avatar than when working directly with the teacher (Anyaegbu et al., 2012).

Levels. A common category of these studies were multiple levels and milestones in games. In most of the studies, levels were connected to specific goals and outcomes (Choi, 2014). A new level has also been used when a new concept needs to be introduced, which helps students to focus on one concept at a time and explore the next one when mastery has been

achieved (Anderson & Barnett, 2013). Similarly, the use of levels can be used when multiple goals are embedded in the game or instruction and learners need to demonstrate mastery before moving to the next one (Beserra et al., 2014). Teachers and researchers can assess and collect data at each level, which can provide evidence of learning early on and in multiple milestones and not just at the end (Muehrer et al., 2012).

Self-monitoring features. Several of the games in this integrative review had self-monitoring features that allowed learners to monitor their progress, as well as their learning status (Chen & Lee, 2018). These self-monitoring features contribute to self-directed learning. Most of the games in these studies allowed students to work at their own pace and make their own choices, which is something they admitted they enjoyed and contributed to their learning (Anyaegbu et al., 2012; Beserra et al., 2014; Brom et al., 2010).

In some instances, these self-monitoring features are present in the form of scores (Cheng et al., 2017), while others show the rate of progress (Beserra et al., 2014). The use of self-monitoring features can contribute to self-directed learning and metacognition, as learners can know by themselves the progress they have made and the progress that they are still required to make (Suh et al., 2010). Also, self-monitoring features can contribute to a sense of fulfillment as the learner becomes aware of the milestones and challenges they have overcome.

In addition, many games embedded scaffolding features that players could access only if they felt they were necessary to improve their understanding and performance (Lin et al., 2013). This allowed students to work with content that really mattered to them and that they felt was necessary, which might help with engagement and meaningful learning.

Audiovisual elements. Learners from the studies that were considered for this integrative review expressed excitement about the rich audiovisual elements of games (Ke & Abras, 2013).

This excitement has also been linked to higher levels of motivation and engagement in the classroom, as shown in interviews of learners conducted by Anyaegbu et al. (2012): "'What motivated and engaged me to use *Mingoville* to learn English is the vivid and rich colors used to design *Mingoville* platform which made it to look real'"(p.160).

Besides the excitement (Huang et al., 2014), which can contribute to an effective learning experience, these audiovisual elements in games present multiple representations of knowledge and cater to different types of learning preferences (Muehrer et al., 2012). In many games, information and content is presented through a mix of formats such as text, animations, and audio (Papastergiou, 2009). This can help keeping the attention and engagement of learners, regardless of how they prefer to acquire knowledge. In addition, the audiovisual elements of games can provide a visual support for students. For instance, some games can use color to reveal hints and to help learners when they are struggling in an area of the game (Hung, Kuo, Sun, & Yu, 2014). Other games narrate the storyline, instead of using text, which caters to students who prefer audio over text when learning (Muehrer et al., 2012).

Adaptivity. The design of adaptive games is rooted in adaptive learning, which has been an easy and effective way for students to learn (Ibrahim, Hamada, Elleithy, Badara, & Moslehpour, 2018). Many digital games, especially the learning ones, are adaptive in nature. An adaptive game customizes its content, goals, or challenges, based on the performance and/or answers of the player ("Authoring Adaptive Games," 2018). The adaptivity of games can be connected to effective learning since learners in these studies were able to ask their teachers for assistance in a timely manner (Chang et al., 2012), review materials (Tsai, 2016), or access resources embedded in the game to improve their performance (Chen & Lee, 2018).

One of the most common features of these adaptive games is the increase in difficulty, as the learners make progress and demonstrate a satisfactory performance (Anderson & Barnett, 2013; Mat Zin & Masrop, 2010). Also, the amount and complexity of content can increase as the learner moves forward, ensuring that the learner receives more difficult information once they have mastered the fundamentals (Suh et al., 2010). Conversely, when the performance of a learner is not satisfactory, the level of difficulty can decrease in the game (Mavridis et al., 2017).

Moreover, Mavridis et al. (2017) conducted a study with a flexible game, which allowed teachers to change the content of the game as needed, so it fits instructional plans. The administration panel of this game allowed the teachers to make these customizations without any programming skills, which did not require additional skill development from the teacher. Teachers could benefit their students when customizing and adapting instruction, based on the performance and needs of their students, They could modify the game to fill any knowledge gaps and to focus on the subject matter areas that were really important and necessary for the students.

Competition. Several learners also claimed that competition was a factor that kept them motivated in the learning process (Mavridis et al., 2017). In many studies, the competition factor of the game was at an individual level, encouraging learners to outperform their peers (Chen et al., 2018), while in others, learners had to work in teams and outperform other teams (Yang, 2015). Games that had the competition factor in their dynamic allowed learners to monitor the performance of their other peers (Tsai, 2016), as well as to see their own performance in comparison to their other peers (Chen et al., 2018).

Usability. Game usability can be defined as the ability to use a game in an easy, effective, and efficient way (Barnett, Harvey, & Gatzidis, 2018). Similar to other instructional technologies, the effectiveness of DGBL could be negatively affected by implementing games

that do not comply with basic usability testing. The main usability feature that a game should have is being easy to play (Hsiao, Chang, Lin, & Hu, 2014). When a game is too difficult to use, the overall experience for the learner can be negative and learning might not be effective (Hwang, et al., 2015). The games studied in this integrative review had characteristics that comply with usability.

Those games that were effective for learning were intuitive (Papastergiou, 2009) and easy to comprehend, so students could spend more time focusing on actual playtime and not on the process of learning how to play the game (Ke & Abras, 2013). Many games had interfaces that were easy to navigate and were not too distracting (Beserra et al., 2014), while others had an appropriate length which helped learners to keep momentum and engagement (Costu, Aidin, & Filiz, 2009). This consideration about the length of a game is very important for teachers implementing DGBL in their classrooms, since teachers have specific amounts of time to deliver instruction (Papastergiou, 2009). Furthermore, the studies reviewed showed that usability was possible because students had easy access to the technology and the game was running without issues or delays (Shah & Foster, 2014; Suh et al., 2010).

Summary. In summary, several interactive elements of games were found in this empirical studies and could be responsible for effectiveness in these studies. These interactive characteristics and elements of games include: (1) feedback and rewards, (2) goals and rules, (3) challenges, (4) narrative, scenarios, and characters, (5) levels, (6) self-monitoring features, (7) audiovisual elements, (8) adaptivity, (9) competition, and (10) usability.

Application of instructional design principles. The second theme that emerged from the data in this study was the application of instructional design principles. Even though it could be assumed that effectiveness had to do only with the affordances and characteristics of the

game, these studies demonstrated that sound application of instructional design principles was present to make learning effective.

Analysis. Some games were effective because an analysis of the population was carried out to make decisions about the design and characteristics of the game (Adisti, 2016; Annetta et al., 2009). Even though many games of the study were commercial and available for purchase, others were designed especially for the intervention. Involving the teachers in the early stages of the game design, such as the analysis, can ensure the final product is aligned with the needs of the learners, the instructor, and the course content.

Use of learning and instructional design theories/models. Many of the studies relied on learning or instructional design theories and models to guide the process or design of the game. Some of these theories and models are information-processing theories (Chen et al., 2018), signature pedagogy (Miller et al., 2012), 5E's (Engage, Explore, Explain, Elaborate, and Evaluate) instructional model (Chen et al., 2014), technology acceptance model (Cheng et al., 2013), content and language integrated learning (Dourda et al., 2014), cognitive-affective interaction model (Hsiao, Chang, Lin, & Hu, 2014), learning style theory (Hwang, Sung, Hung, Huang, & Tsai, 2012), the play curricular activity reflection discussion model (Shah & Foster, 2014), self-determination and self-efficacy theories (Eseryel et al., 2014), and others.

Alignment with subject matter. A recurrent category in this study was the alignment of the game with the subject matter. Most of the games used in these empirical studies had strong connections between the content of the class and the content of the game (Denham, 2015; Schifter et al., 2012).

In many studies, the subject matter was embedded in a stealthy way, which allowed students to learn and apply knowledge from the course without even realizing it. For instance,

Chen et al. (2015) ensured that scientific knowledge was embedded in the narrative and goals of the game. Similarly, Chen et al. (2018) embedded the subject matter of physics into a competition game for 7th graders. Similarly, the game *Alchemist' Forts* embedded scientific facts into an engaging game to increase motivation and learning performance (Chen et al., 2014). Cheng et al. (2017) integrated biology knowledge into the game *Virtual Age* to immerse learners and facilitate learning of complex facts in an easier way.

In some studies, teachers and researchers have aligned the design of the game and the subject matter using educational standards required by their governments or institutions. Cheng et al. (2013) based the design and the content of the game on guidelines from the Ministry of Education of Taiwan. Similarly, Liu et al. (2014) aligned National Science Standards and Texas Essential Knowledge and Skills standards with the content of the game to be used in the intervention. Another example was presented by Meluso, Zheng, Spires, and Lester (2012) who based the game content of *The Crystal Island* on the Full Option Science System and the North Carolina Standard Course of Study on landforms and ecosystems.

External learning activity and materials. The instructional activities that took place in these studies, outside of game time, include: lecture (Dorji et al., 2015), drill and practice (Young & Wang, 2014), individual and group reflection (Hwang et al., 2015; Young & Wang, 2014), problem-based activities (Shah & Foster, 2014), reading (Tsai, 2016), peer reviews (Yang, 2015), and journaling (Dourda et al., 2014; Simpson & Clem, 2008). Moreover, during these interventions, learners used a wide variety of learning materials, such as written documents and manuals (Anderson & Barnett, 2013; Chen et al., 2015), worksheets (Chen et al., 2014), digital videos (Hung, Huang, & Hwang, 2014), and textbooks (Yang, 2012).

Embedded assessments. A common trait of these studies was the use of embedded traditional assessments, such as quizzes and multiple-choice tests, in the game (Huang, Wu, & Chen, 2012: Lin et al., 2013). Research has demonstrated that embedding assessments and diagnostic mechanisms in the game cannot only make learning effective, but also contribute to better learner's attitudes towards a subject matter (Huang et al., 2014). In those instances, it is important to have data collection mechanisms to be able to gather the data from these embedded assessments (Muehrer et al., 2012). Some games collect data early on in the game to determine how much prior knowledge the learners have about the subject matter (Panoutsopoulos & Sampson, 2012; Simpson & Clem, 2008; Suh et al., 2010). The use of feedback, as previously explained in this chapter, also contributed to the effectiveness of the embedded assessments (Tsai, 2016). Learners were able to clarify misconceptions or review materials in a timely manner when feedback indicated there was a deficiency in performance (Chu & Chang, 2014).

Scaffolding. Scaffolding can be defined "as the assistance provided to the learner by the teacher or a more knowledgeable peer in order to move the learner into the zone of proximal development" (Abadikhah & Valipour, 2018, p. 152). Even though scaffolding is not an element that is present in all games, most of the games designed for these studies had a sound use of scaffolding through techniques such as prompts (Denham, 2015), cues (Wu, Chen, & Huang, 2014), hints (Hwang, Chiu, & Chen, 2014), suggestions (Wu et al., 2014), illustrative examples (Shah & Foster, 2014), guidance to find resources when learners failed to answer correctly (Hwang, Wu, & Chen, 2012), activation of prior knowledge (Chang et al., 2012) and increased level of difficulty in challenges (Young & Wang, 2014). On the other hand, scaffolding from the teacher was also a part of some of these studies. In a study conducted by Yang (2015), teachers helped students who were not sure about what to do in the game as they were making progress.

In addition, in this study, teachers used modeling to teach learners how to effectively use the game and have a strong performance (Yang, 2015).

Summary. The application of instructional design principles was demonstrated through: (1) analysis, (2) use of learning and instructional design theories and models, (3) alignment with subject matter, (4) external learning activities and materials, (5) embedded assessments, and (6) scaffolding. In the particular case of scaffolding, it was not included in the interactive elements and characteristics of game, because in these studies it was found related to instructional decisions to enhance learning.

Active learning. The third theme in this study was active learning. By definition, "active learning is a broad term for instructional methods that engage students through meaningful learning activities that require students to solve a problem or task" (Sibona & Pourreza, 2018, p.67). Participants in the studies of this review have acknowledged that playing games in class made it more active than when they are using other instructional methods (Anyaegbu et al., 2012).

Problem-solving and completing tasks. The fact that learners are solving problems and completing tasks requires active learning and can have an impact on effectiveness. First, learners in these studies have expressed that having to solve problems and complete tasks kept them motivated (Anyaegbu et al., 2012). Second, problem-solving and completing tasks foster the application of knowledge in students (Chen et al., 2014) and even the acquisition of knowledge in some instances (Hsiao, Chang, Lin, & Hu, 2014). Third, problems and tasks can keep learners engaged for a longer time, since they are focused on working on solutions (Hwang et al., 2017).

Collaboration. Another strategy of active learning that learners adopt when playing games is collaboration. Most of the games in this review encouraged collaboration in students at

different levels. In some instances, learners had to play the games in pairs (Annetta et al., 2009), or in larger teams (Brom et al., 2010), while in other instances collaboration took place because a learner could help or give suggestions to other peers in the classroom, even if they did not have to play the game together (Hsiao, Chang, Lin, Chang, & Chen, 2014). Consulting with other peers to find alternative solutions and strategies when failure was experienced during the game was a feature that many students appreciated in these studies because it really fostered a collaborative environment (Chen et al., 2015). Collaboration in these games also allowed team members to leverage their strengths and choose different roles to complete the game activities (Dourda et al., 2014; Miller et al., 2012). Many students pointed out that these collaborations while playing did not only make learning more effective, but that they fostered interpersonal relationships (Hsiao, Chang, Lin, Chang, & Chen, 2014).

Role-playing. When learners engage in game play, they usually get involved in role-playing, depending on the game content and dynamic. Several studies in this review had designs that fostered role-playing in students. In the games included in this review, learners played the role of a scientist (Liu et al., 2014), worked in restaurants (Mat Zin & Masrop, 2010), lived the life of a king (Sung & Hwang, 2013), faced the challenges of being a writer (Warren et al., 2009), and learned how to deal with difficult customers (Wu et al., 2014). This affordance of digital games helped to increase the engagement of students while they were playing (Warren et al., 2009).

Summary. In summary, DGBL can be effective because of its implementation in the classroom fosters active learning due to the activities the student engages in, such as: (1) problem-solving and completing tasks, (2) collaboration, and (3) role-playing.

Learner's characteristics and attitudes. The fourth theme identified as a possible influential factor in K-12 DGBL is learner's characteristics. In the case of DGBL, studies have shown that learner's characteristics play an important role in effectiveness as well. The following categories, based on this integrative review, describe the learner's characteristics that potentially influenced learning from digital games.

Learner's prior experience with the subject matter. In most of the studies in this integrative review, learners had a lot of prior experience with the subject matter. In many of these studies, learners gained a lot of experience with the subject matter through lectures, handouts, and textbooks (Chen et al., 2015; Dourda et al., 2014). Suh et al. (2010) found that there was a correlation between learner's prior knowledge and achievement in the digital game used in this study.

Learner's familiarity with games. Shah and Foster (2014) conducted a study in which learners played games during the duration of the whole course to learn about systems thinking. The argument was that the more games a learner plays, the more they will be used to the technology, which can have a positive effect on learning. In addition, appropriate training can help learner's increase their familiarity with any tool. Many of the studies provided training for students to learn how to play the game and become more familiar with the technology (Meluso, et al., 2012). Most of the game training for students took the form of tutorials (Muehrer et al., 2012; Yang, 2015). In other instances, teachers and researchers provided face-to-face training, game demonstrations, or printed resources in advance, so students knew about the game controls, rules, and the game content in each level (Chen et al., 2014; Denham, 2015; Dourda et al., 2014; Panoutsopoulos & Sampson, 2012).

Learner's attitudes. Most of the studies that claimed learning effectiveness demonstrated that learners had a positive attitude towards the game and learning with a game (Brom et al., 2010; Muehrer et al., 2012). Positive attitudes towards DGBL were due to the perceived usefulness of the games (Cheng et al., 2013), the engaging presentation of the class material through the game (Chen et al., 2015), or because the game was designed using real data and situations (Brom et al., 2010).

Summary. In summary, the learner plays a very important role in the effectiveness of implementation of DGBL through their: (1) prior experience with the subject matter, (2) familiarity with games, and (3) attitudes.

Teacher's role. The fifth and last theme found in this integrative review was the role that teachers play when implementing DGBL in their classrooms. As found in the "application of instructional design principles" theme, many teachers still engaged in traditional teaching activities, such as lectures, when implementing DGBL in these studies. However, there were other roles that they assumed, especially during play time.

In these studies, professional development and resources, such as training, were available to help teachers assume these roles (Shah & Foster, 2014). These training sessions included topics like how to play the game, the content of the game, and some DGBL pedagogical considerations (Muehrer et al., 2012; Schifter et al., 2012; Shah & Foster, 2014).

Teacher as facilitator. The most important role that teachers assumed in these studies was the role of facilitators. In many studies, teachers shifted their approach while students were playing the game in the classroom, providing support to them (Brom et al., 2010). Some teachers were in the classroom to monitor the learner's activities and progress and to answer questions and offer suggestions about the game (Chang et al., 2012). Also, teachers were available to

provide scaffolding to students as required (Yang, 2015). In some studies, the assistance provided by teachers was limited to pointing out to students where to find resources and how to use them if they were struggling or facing challenges (Warren et al., 2009). In other instances, teachers supported the research studies by customizing their lessons, so the DGBL intervention could take place without challenges or delays (Yang, 2015). Teachers were also available to organize the logistics of the research studies (Muehrer et al., 2012; Panoutsopoulos & Sampson, 2012).

Teacher involved in game design. In some instances, the teacher was the actual game designer (Annetta et al., 2009), while in others, the teacher contributed to the testing of the game to ensure it was valid and aligned with the desired learning outcomes (Adisti, 2016; Hsiao, Chang, Lin, & Hu, 2014; Suh et al., 2010).

Teacher as influencer. In addition, teachers can influence students to appreciate and value learning through games, which can also enhance learning in students (Anyaegbu et al., 2012). The positive attitudes of the teacher can be connected to a higher level of influence over their students as pointed out by Muehrer et al. (2012).

Summary. In summary, even though learners engage in active and self-directed learning when using digital learning games and researchers have played an important role in conducting these studies, this integrative review has demonstrated that there is still an important role for teachers. The roles for teachers implementing DGBL can be: (1) teacher as facilitator, (2) teacher involved in game design, or (3) teacher as influencer.

Summary of research question #3. There are factors and elements that belong to the game, and beyond the game, that could have influenced learning in these 66 empirical studies that claim effectiveness. Five overarching themes were found in these studies: (1) interactive

characteristics and elements of games, (2) application of instructional design principles, (3) active learning, (4) learner's characteristics and attitudes, and (5) teacher's role. Each one of these themes have categories that are presented in Table 11 and Figure 5. Also, Appendix C provides a coding dictionary that shows the relationship between these themes and categories.

Table 11

Possible influential factors in K-12 DGBL effectiveness.

Themes	**Categories/Codes**	**Frequency**
Interactive Elements of Games	Feedback and rewards Goals and rules Challenges Narratives, scenarios, and characters Levels Self-monitoring features Audiovisual elements Adaptivity Competition Usability	278 times
Application of Instructional Design Principles	Analysis Use of learning and instructional design theories/models Alignment with subject matter External learning activities and materials Embedded assessments Scaffolding	124 times
Active Learning	Problem-solving and completing tasks Collaboration Role-playing	115 times
Learner's Characteristics and Attitudes	Prior experience with subject matter Familiarity with games Attitudes towards game/content	29 times
Teacher's Role	Teacher involved in game design Teacher as facilitator Teacher as influencer	24 times

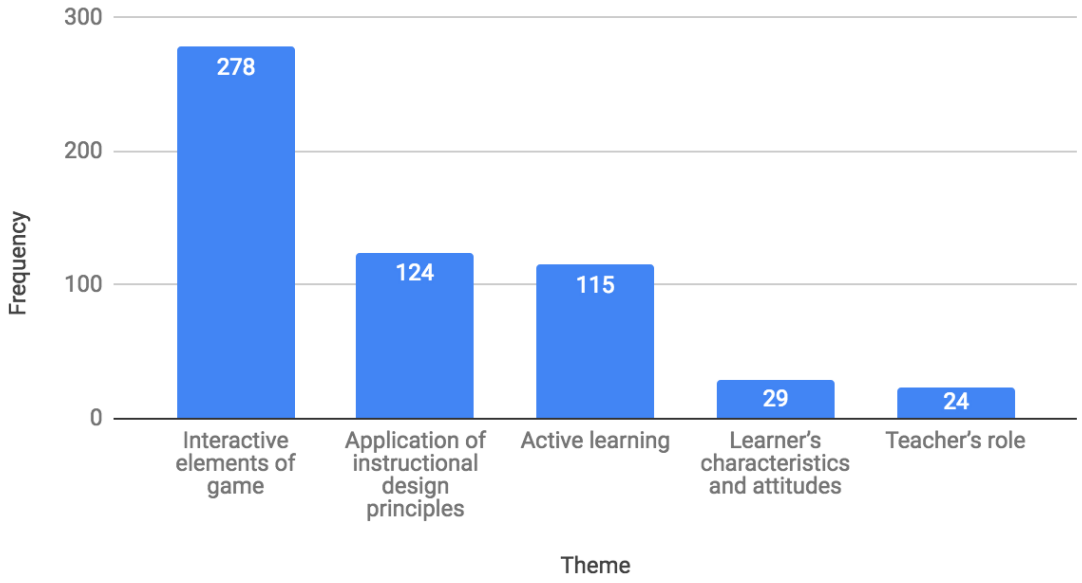

Figure 6. Quantification of themes: Possible influential factors in K-12 DGBL.

Research Question #4

The fourth and last research question *"What areas or issues in K-12 DGBL still need to be studied in order to contribute to its effectiveness and advancement of the field?"* focuses on a research agenda for the advancement of K-12 DGBL, and therefore, instructional design and technology. Research agendas are one of the deliverables that are common in integrative reviews and they should be developed based on the findings and gaps in the review (Horne & Sandmann, 2012). Based on the results of the previous three research questions and an overall evaluation and interpretation of the data that emerged from this study, the following areas in K-12 DGBL should

be investigated or explored in further detail. Figure 7 provides a classification of this research agenda.

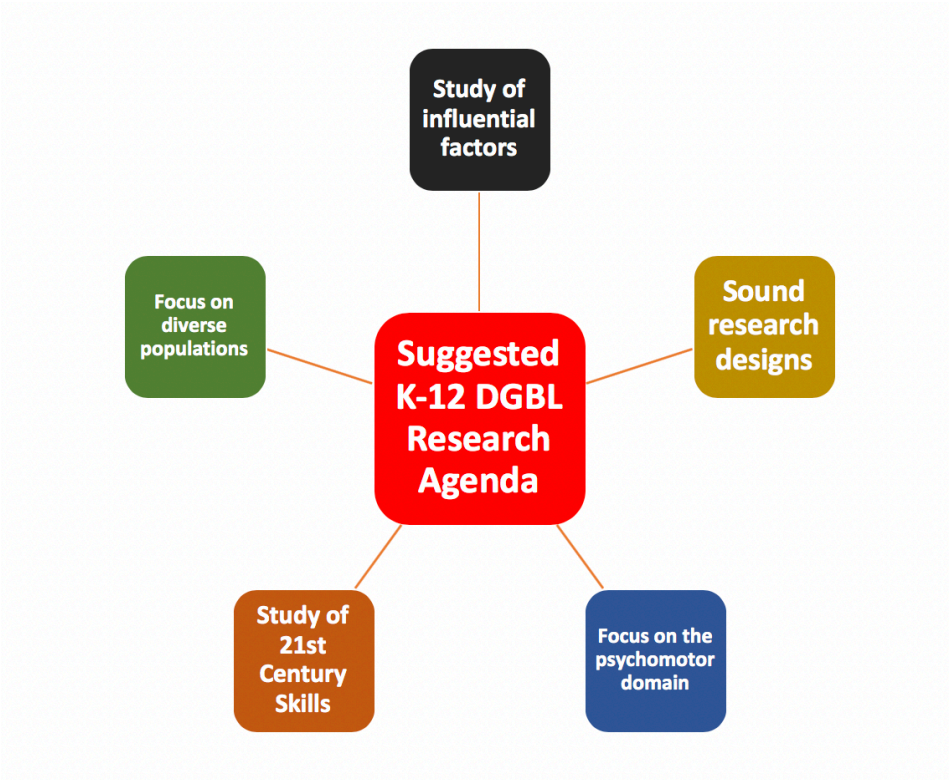

Figure 7. Suggested K-12 DGBL research agenda.

Study of influential factors in instruction. The findings of research question #3 made the case for factors, beyond the digital game, that could be influencing learning and effectiveness in the empirical literature. The analysis of these factors demonstrated that these factors, even if used as independent factors, can have positive effects on learners in terms of engagement, motivation, and knowledge acquisition (Anyaegbu et al., 2012; Chen et al., 2018).

A new trend, called gamification, which consists of adopting elements or characteristics of games to increase engagement in learning, has increased in adoption by teachers and instructors (Chen et al., 2018; Liu, Santhanam, & Webster, 2017). This study provides evidence that the inclusion of factors present in games such as feedback, rewards, and challenges can

make learning effective, but that in order to fully have an effective learning experience, other factors beyond those interactive game elements or characteristics need to be taken into account, such as the characteristics of the learner, the role of the teacher, or the sound application of instructional design principles.

It is then suggested that researchers conduct more empirical and rigorous studies to find scientific evidence that these factors are actually playing a role in K-12 DGBL effectiveness. Even though the scientific study of gamification has started producing results about effectiveness (Hursen & Bas, 2019), future research in K-12 DGBL should not only focus on the game elements or characteristics, but other factors that take place in the classroom and study how they have an impact on learning. Very few studies in this integrative reviewed analyzed if other factors, beyond the game, had an impact on effectiveness.

Sound research designs for K-12 DGBL. Consistent with other studies that point out the need for higher quality DGBL research (Jabbar & Felicia, 2015), this integrative review also suggests new alternatives to improve research in the field. Media comparison studies have been a frequent problem in the instructional design and technology field for decades (Clark, 1983; Warnick & Burbules, 2007). Even recent studies use this type of research design to measure learning effectiveness when implementing an instructional technology (Chen et al., 2018; Chen & Liu, 2018). Findings from this study have shown that media comparison is a problem of K-12 DGBL research, since more than half of the studies analyzed in these reviews used it as a research design. In addition, results from this study did not show unique features or elements in games that cannot be found in other media. This finding indicates that there is a need for better and more effective research designs in K-12 DGB research, since media comparisons could only be considered as a suitable option when these unique and exclusive attributes are found in media

(Clark, 1983). This suggestion is aligned with other studies that have promoted research agendas with research designs that can advance the field and make research sound and responsible (Lockee et al., 1999).

A sound research design that K-12 DGBL researchers can pursue is design-based research, which was the foundation for just one experiment (n=1) in this study (Anderson & Barnett, 2013). Design-based research has also been promoted as a suitable research design by experts in the field of instructional design and technology (Amiel & Reeves, 2008). In addition, design-based research is aligned with design thinking, which is a promising trend to foster 21st century skills and learning enhancement in students (Noel & Liub, 2017).

Another alternative recommended to K-12 DGBL researchers is longitudinal studies. As this study has shown, a problem in the adoption of games in K-12 settings is short interventions. Some interventions go as short as 1 day which cannot make a strong case for effectiveness. Longitudinal studies can be beneficial not only to foster longer interventions in DGBL, but also to study the actual transfer of knowledge that students can experience long-term as a result of the game play in class. In education, longitudinal studies have been effective to identify the evolution that learners go through and the changes in knowledge or attitudes over time (Linjawi & Alfadda, 2018). K-12 populations offer an advantage for researchers in comparison to other populations as it is common for many students to remain in the same school for several years, which can make cohort studies feasible.

In addition, researchers can benefit from the value that qualitative methodologies add in terms of descriptions and details for implementation (Merriam & Tisdell, 2016). As seen in this study, the qualitative methodology was not a prevalent theme and other researchers have also noted the need for more qualitative studies (Connolly et al., 2012).

Besides these suggestions for new research designs, researchers should consider the issues presented in research question #2 about problems in the K-12 DGBL empirical literature. By avoiding these problems in future studies, researchers would be contributing to a more socially responsible research agenda as Reeves suggested in his work (Reeves, 1993, 1995). Even though other researchers might not see problems in the themes found in research question #2, those findings have been identified in the literature as flaws in research.

Focus on the psychomotor domain. This review only found three (n=3) articles that focused on the psychomotor domain (Hsiao, Chang, Lin, & Hu, 2014; Hsiao & Chen, 2016; Simpson & Clem, 2008). The psychomotor domain is very important since it is allows for students to learn and demonstrate expertise in manual skills (Mohamad, Yee, Tee, & Ahmad, 2017). This includes activities such as playing instruments, dancing, using tools and software, playing sports, cooking, and others. There has been a lot of research done about the psychomotor domain and how it can be measured and assessed (Nathan, Berahim, & Ramie (2017). In addition, this review showed than digital games have produced positive outcomes for learning activities related to this domain (Hsiao & Chen, 2016). For this reason, K-12 DGBL researchers should consider not only focusing on cognitive or affective studies, but also in psychomotor ones. There are so many psychomotor skills that need to be fostered in K-12 learners and DGBL has the potential to do that.

Study of 21st century skills. 21st century skills, such as creativity, communication, critical thinking, and collaboration have a focus of study in teaching and learning because of the needs that students have to develop them (Anagun, 2018). However, the literature has identified that the study of these 21st century skills needs more work (Chalkiadaki, 2018). Only six studies

(n=6) used 21st century skills as a dependent variable (Chang et al., 2012; Ott & Pozzi, 2012), with five (n=5) out of those six making claims about learning effectiveness.

Given that the need for 21st century skills is a theme in the literature, that DGBL has been an effective strategy to foster these skills, and that few studies have focused on the use of games to foster them, it is recommended that researchers investigate the use of DGBL to enhance learning and promotion of 21st century skills in K-12 classrooms.

Focus on diverse populations. One study (n=1) focused on students with special needs (Ke & Abras, 2013) with results that demonstrated learning effectiveness. In addition, K-12 DGBL has been thoroughly implemented in Asia, but not so much in other areas such as Latin America, Africa, and parts of Europe. This evidence points out the need to expand K-12 DGBL research to diverse populations. Since positive outcomes and experiences have been extensively reported in those empirical studies, it would be beneficial for researchers to use DGBL in areas and with populations that do not have access to new instructional technology or where challenges in education have been identified. It could be useful to determine if the benefits seen so far are also applicable to other settings. This could also be an opportunity to inform teachers and practitioners who work with diverse populations and from other geographical areas about the data-based benefits of learning games.

Summary of research question #4. The need to study possible influential factors, including elements of the game and external to the game, is aligned with gamification studies that have become more prevalent in instructional design and technology in recent years. Results from this integrative review make the case for the need to further investigate gamification and what possible influential factors are actually responsible for learning enhancement. In addition, the need for sound research designs that do not use media comparison is still a need in the field.

By using alternatives such as design-based research or longitudinal studies, and by avoiding the flaws presented in research question #2 researchers could be moving towards a more socially responsible research agenda as outlined by Reeves (1993). This could be also achieved by working with diverse populations in the implementation and study of K-12 DGBL effectiveness. Finally, learning in the psychomotor domain and the fostering of 21st century skills can be achieved through DGBL, as results from studies have shown in this review. This all could be areas for future research in K-12.

Summary of Chapter 4

The goal of this integrative review was to evaluate, critique, and synthesize the current state of empirical K-12 DGBL, while producing new knowledge about this topic. As recommended in integrative reviews, the researcher provided a series of conceptual classifications, tables, and a research agenda as part of this new knowledge generated, and as recommended by experts in the methodology (Torraco, 2005).

The first research question provided descriptive statistical information that summarizes what has been studied in K-12 DGBL, including countries, knowledge domains, types of games, subject matters, population samples, research designs and methodologies, research instruments, dependent variables, and outcomes. The goal of this research question was for researchers and practitioners to be fully aware of what has studied when effectiveness claims about K-12 DGBL have been made. In that way, they can potentially determine to what extend results can be generalized and applicable to their settings.

The second research question provided qualitative information about problems found in K-12 DGBL empirical literature. Eleven possible flaws in K-12 DGBL research were identified with explanations about why they were considered problems. In addition, the researcher provided

examples of studies that had these problems, so it could be used as reference by other researchers interested in investigating deeply these issues.

The third research question provided a qualitative investigation of possible influential factors that could be responsible for K-12 DGBL effectiveness. Some of these factors were related to characteristics and elements of the game, while others had to do with the learner, the environment, instruction, and the teacher. One goal of this research question was to look for evidence to possibly justify media comparison studies, if unique attributes of games could be found. However, no exclusive interactive elements and characteristics of games were found, which supports Clark's (1983) point of view about media not influencing learning. In addition, his points of view is further supported because this research question found that there were other factors not related to the game, such as learner's characteristics and attitudes and the application of instructional design principles that had an impact on learning. It is clear from this research that DGBL is a system that has multiple parts, not just the game, and that successful implementation requires paying special attention to all these factors.

The fourth research question was designed to identify research agenda, based on all of the gaps found in the review of 72 empirical journal articles. Research agendas are not only a suggested deliverable in integrative reviews (Torraco, 2005), but also an identified need by experts in instructional design and technology (Reeves, 1995). This question covers areas that should be further investigated, based on evidence from this study.

In the next chapter, a discussion of the findings will be provided, as well implications for researchers and practitioners. Finally, a conclusion will be presented by the researcher.

CHAPTER 5

DISCUSSION & CONCLUSIONS

This chapter presents a discussion of the findings of this integrative literature review. The goal of this study was to analyze empirical K-12 DGBL literature and effectiveness claims that these studies might present. Integrative literature reviews can be considered an effective research design because they can be used to synthesize, critique, and evaluate mature topics with the goal of producing new knowledge or reconceptualizations (Torraco, 2005).

As DGBL can be considered a mature topic that has been officially advocated for and studied since the early 2000s (Prensky, 2001), the researcher identified an opportunity to evaluate existing empirical evidence and report on findings, especially in terms of effectiveness of DGBL for K-12 populations. Several effectiveness claims have been made in the literature (Chen et al., 2018) and the researcher found it pertinent to report on the implications and limitations of these claims, so they could be used in a more responsible manner. Another need for this type of study is that several meta-analyses, systematic reviews, and literature reviews have been conducted for DGBL, but instead of using a critique/evaluation approach, researchers have mostly used a summarizing one (Connolly et al., 2012). The same is true of existing DGBL integrative reviews (Tan el al. 2017). In other instances, the scope of these reviews has been too broad, which does not allow findings to be generalizable to a specific population (Wu et al. 2012).

In addition, the researcher's familiarity with Reeves's (1993, 1995) framework of pseudoscience that addresses problems in instructional design and technology research was a motivation to determine if current empirical K-12 DGBL literature has any of these or other measurement flaws. By reporting on research problems and gaps found in the literature,

effectiveness claims in K-12 DGBL could be effectively evaluated and future studies could be improved, contributing to a more socially responsible research agenda. The researcher also wanted to study if effectiveness claims were only dependent on the use of digital learning games or if there were other factors that played a role in effectiveness, as described by Clark (1983).

In this study, the researcher was able to accomplish these initial goals. First, the researcher was able to present a summary of the current status of the literature, in terms of research designs, instruments, variables, and outcomes in K-12 settings. Second, the study identified relevant problems in empirical studies related to the use of digital learning games in K-12 classrooms, including media comparison and lack of definition of variables to mention a few. Third, the study carefully and thoroughly analyzed the articles in this review and identified possible influential factors and conditions that could have impacted the effectiveness of learning, beyond the actual digital game. Finally, the researcher provided a research agenda with new perspectives that could be considered and included in future K-12 studies, based on gaps in the empirical literature.

As is the nature of integrative reviews, this study was qualitative in nature. It also focused on four overarching research questions to carry out the analysis:

1. How is the effectiveness of DGBL in K-12 being studied in empirical literature, including research designs, instruments, variables, and outcomes?
2. What problems are found in the literature regarding the study of effectiveness in K- 12 DGBL?
3. What factors or conditions might be influencing the effectiveness of K-12 DGBL in these empirical studies?

4. What areas or issues in K-12 DGBL still need to be studied in order to contribute to its effectiveness and advancement of the field?

Discussion of Findings

Results from the first research question *"How is the effectiveness of DGBL in K-12 being studied in empirical literature, including research designs, instruments, variables, and outcomes?"* showed that most of the studies have been conducted in the Asian continent, especially in Taiwan. In a distant second, place several studies were conducted in North America, especially in the United States. These results show the claims about effectiveness and most of what we know about the implementation of DGBL in K-12 settings can be generalized to two geographical areas. Even though it is possible to assume some of the steps in adoption could be applied to other areas, school culture and differences in educational systems in other parts of the worlds might alter the results. For this reason, researchers and teachers interested in using evidence from these empirical studies should pay attention to how their schools and overall educational culture could make the process easier or more difficult.

Furthermore, Africa has not been found to be a continent with a K-12 DGBL culture in classrooms, based on findings of this study. Even if the full implementation of actual digital games is not possible in some parts of Africa due to restrictions in technology and resources, this study can inform teachers, researchers, and administrators of elements in DGBL that could be independently adopted to enhance learning and make it more effective. As research has demonstrated, digital technologies have been identified as potential tools to enhance learning in developing countries (Kalolo, 2019).

Another result of the first research question is the subject matters that were investigated in K-12 DGBL studies. Most of the studies focused on STEM fields, while a minority focused on

social sciences and languages. Recent DGBL reviews have focused on these subject matters, which can be connected to the large amount of existing studies in these areas (Byun & Joung, 2018; Tsai & Tsai, 2018). Extensive implementation of DGBL in STEM fields can also be linked to the fact that funding for STEM-related disciplines is more available than for other disciplines (Rincon & George-Jackson, 2016). On the other hand, research has demonstrated that using STEM-related activities during earlier years can help change the attitudes and performance of students in STEM fields, which tend to be challenging and difficult for many students (Ugras, 2018). Games have been known to also contribute to students looking at STEM fields in a different way and to have more effective learning experiences (Costu et al., 2009). For this reason, there should be a consideration for institutions, teachers, and researchers to use games in other fields to enhance learning. Besides mastery in STEM fields, students also need a competitive performance in others domains such as languages to be successful (Danijela & Mladen, 2013).

Findings from question one also showed the most studied knowledge domains were cognitive and affective, but rarely the psychomotor. Even though the psychomotor domain has not been the main focus of these studies, it is important to also note the relevance of this domain in education (Mohamad et al., 2017). There are several psychomotor skills such as the use of tools and software, dancing, or sports that are part of K-12 education and that learners might struggle with Games have been beneficial for the enhancement of this domain, as this integrative review has found (Hsiao & Chen, 2016). These results are aligned with others that state how video games can help learners make meaningful and effective translations into psychomotor practices (Adachi & Willoughby, 2016). For this reason, teachers and researchers should consider DGBL as an effective strategy in the psychomotor domain, given that factors in DGBL

such as audiovisuals, feedback, and active learning can contribute to a more effective experiences in this domain.

In addition, most of the studies found in the K-12 DGBL literature are experimental and use quantitative or mixed methods. Even though case studies and qualitative methodologies are the minority, this study reflects they were very effective describing interventions, data collection procedures, and the context of the implementation of digital games (Warren et al., 2009). These findings are aligned with other studies (Hung, Yang, Hwang, Chu, & Wang, 2018), which discuss a lack of qualitative studies in the literature. Qualitative studies, and mixed studies with thorough qualitative descriptions, allow other researchers to fully understand the experience of students using digital learning games in learning. The thorough descriptions found in the qualitative studies from this review provided adequate information from which to draw conclusions and analyze the majority of factors playing a role in instruction. For this reason, the researcher of this integrative review finds it pertinent to suggest more qualitative studies in K-12 DGBL.

A frequent theme in the results of this integrative review was the use of pre/post tests to measure effectiveness. Even though there are no statistical or scientific problems with the use of these instruments, they have been criticized because of how they can influence learners to perform better or worse just because of their structure or because they can facilitate or confound learning, and not because of the intervention being measured (Phillips & Myers, 2013). For example, researchers might consider diversifying their instruments to other options such as the retrospectives pre-tests (Thomas et al., 2019). Instead of administering two tests (before and after the intervention), researcher can simply administer one test after the intervention to help

participants reflect on how much their learning and knowledge acquisition changed as a result of the intervention.

In terms of dependent variables, most of the studies focused on the measurement of content knowledge, with also a strong presence of studies analyzing changes in attitudes or engagement. However, the study of 21st century skills such as collaboration, critical thinking, communication, and creativity was not substantially present. Given how these skills are considered fundamental for the success of students (Spies & Xu, 2018), results of this review demonstrate the need to use DGBL to foster them. Frequently, teachers struggle with the fostering and the assessment of these 21st century skills due to their complexity (Anagun, 2018), so digital games can be one of the alternatives they can use to face this challenge.

On the other hand, almost all of the studies in this review demonstrated effectiveness of DGBL in at least some of the variables being studied. By looking at these numbers, an assumption can be made that games are effective technologies to enhance learning. However, as researchers have pointed out, it is not instructionally sound to assume that it was just the technology alone that fostered this effectiveness (Clark, 1983; Surry & Ensminger, 2001; Warnick & Burbules, 2007). As this study demonstrated, there are factors in and out of the game, including the teacher and the learner, that play a role in learning effectiveness when implementing DGBL.

The goal of the second research question *"What problems are found in the literature regarding the study of effectiveness in K- 12 DGBL?"* was to identify problems in empirical K-12 DGBL studies and how they could be affecting effectiveness claims. Even though all studies have limitations, the fact that some studies in this review did not report them was one of the problems found in the literature. By acknowledging limitations, researchers can understand more

clearly the scope and how generalizable results are. In addition, the inclusion of limitations can prepare researchers to overcome challenges during their studies and can take steps to design more rigorous studies. Many study limitations were not directly acknowledged in the reports included in this review, but found after an extensive qualitative analysis of them. Future K-12 DGBL should be very specific addressing limitation of the studies.

Besides the issue of limitations, media comparison is still a relevant problem in K-12 DGBL. More than half of the studies included in this review presented the media comparison study problem, as described by Clark (1983). Even though these studies still made claims about effectiveness, teachers and researchers should be mindful of other factors and conditions that could have facilitated learning and not just the technology. Given this study demonstrated that there are other factors and conditions having an impact on learning, researchers should avoid media comparison studies because it is not only media that plays a role in learning effectiveness. Comparing two media would be confounding this media with other factors such as instructional method (Clark, 1983). Furthermore, findings from this empirical study did not find unique elements in digital games, which may have provided a reason to consider media comparison studies, as some researchers have pointed out (Lockee et al., 1999).

In terms of other problems in the empirical K-12 literature, this review found many studies had no relevant connections to instructional design/learning theories or models either to guide the research process or to design the games. This lack of substantial connections to theories or models about learning or instructional design is one of the main problems in the field as explained by Reeves (1993, 1995). Even though Reeve's work about pseudoscience in instructional design has almost three decades of existence, findings from this review demonstrate it is still an issue that requires attention. It is important for researchers and teachers to ensure

both the design of the game and the studies are founded on instructional design theory and what we know about learning. It is troublesome to assume that DGBL was effective to enhance learning when the design of the game and/or research study had no connections with cognition, instructional design, educational psychology, or learning science. Also, having a strong instructional design foundation in the study can give confidence to teachers and researchers to use commercial games. As shown in this review, commercial games are effective in learning if there is a sound instructional design foundation to conduct the research study (Yang, 2015).

Similarly, another problem found in several K-12 DGBL empirical studies is the vague or no definition of variables. Vague or no definition of variables is a problem of pseudoscience as Reeves identified in his studies (1993, 1995). In many of the studies, authors did not define their variables or did not provide a definition that could place the dependent variables into the research context. In many cases, this can be problematic because a variable might have different meanings or interpretations for researchers, hence making it difficult to accurately replicate studies.

Other problems in K-12 DGBL empirical literature include lack of detail about instruments and disclosure of data analysis procedures, as well as no reporting on reliability and/or validity of instruments. There has been a much debate in statistics about the use of the p-value, including that the p value provides inadequate evidence against the null hypothesis (Hubbard, & Lindsay, 2008). Many statistical studies have been conducted and demonstrated that the p-value and the term “statistically significant” are confounded and that the p-value does not mean that the study was necessarily effective or that the outcome was significant (Roychoudhury, Scheuer, & Neuenschwander, 2018). P values are about the population and how randomly it was selected. For this reason, more than making assumptions by looking at p-values

and outcomes, it is important to evaluate and critique aspects of a study such as reliability and validity of instruments, research questions and variables, data analysis procedures, length of interventions, and information about instruments (Hubbard & Lindsay, 2008). Since many studies in this review did not have adequate information about data analysis, instruments, reliability, or validity, the effectiveness of these interventions can be questioned. For this reason, researchers should not focus on the p-value as a measure of effectiveness in their studies, but focus on the overall design of their studies and if reliability, validity, and instrument design/information is presented. These findings are aligned with Reeves (1993) framework of pseudoscience, as he identified issues such as specification error, measurement flaws, inconsequential outcomes measures, and inappropriate statistical analysis were usually found in instructional design and technology studies.

Another problem found in the literature was short interventions of DGBL in K-12 classrooms. Several studies had interventions as short as a day (Hung, Huang, & Hwang, 2014), while in very rare instances they went for years (Ott & Pozzi, 2012). Although it is difficult to carry out long interventions due to limitations in time, budget, and availability of the population, it is not always possible to make claims about effectiveness in learning with extremely short interventions of a day or few days. For this reason, researchers should take this into account in their research designs, and teachers should also take into account how much time they can devote from their classes to these interventions to thoroughly observe changes in knowledge, skills, and abilities. Reeves (1993, 1995) also included in his framework that inadequate treatment implementation, especially short interventions, is one of the problems in instructional design and technology research. In some instances, this can be problematic because it might take time for the student to learn the technology, so time is required for that task alone.

Another research problem described by Reeves (1993) and found in the studies analyzed in this integrative review was the use of small population samples. Even though it could be challenging in research to recruit a large number of participants, small samples can make it difficult to generalize results. Moreover, this integrative review found that many studies used populations with mixed characteristics, such as different age groups or from different grades.

In some cases, studies not did specify the type of research design that was used. Even though assumptions can be made in some instances, not reporting on the type of research design can be problematic for novice researchers or practitioners who do not have a strong research background.

In other instances, studies did not provide specifics about the types of games that were used in the research process. Even though this lack of information might not be perceived as a research problem, the researcher found that not having this information can be a problem for other researchers or practitioners interested in replicating the study or adopting a similar game. Having specific information about the characteristics of the game provides evidence of the types of games and the characteristics necessary to enhance learning. On the other hand, there is an assumption that designed games for a specific class are the only ones that are effective in instruction; however, this study concluded this is not necessarily accurate. 12% of the studies analyzed in this review used commercial games, pointing out that these games were effective in instruction.

One of the main contributions of this integrative literature review is that it has pointed out to what extent studies claiming effectiveness are valid and if there are issues and shortages in the research designs. Other integrative reviews focused on DGBL have simply provided synthesis of work done so far and classifications such as types of games used.

The goal of the third research question *"What factors or conditions might be influencing the effectiveness of K-12 DGBL in these empirical studies?"* was to identify elements in instruction, beyond the actual game, that could have made the learning experience effective. The researcher also deconstructed the digital games and analyzed the elements within these games to study the possible relationship between these elements and effectiveness, as suggested by Clark (1983). Based on this analysis, the researcher found themes that could have played a role in the learning process of students using digital games: (1) interactive elements of games, (2) active learning, (3) application of instructional design principles, (4) learner's characteristics and attitudes, and (5) teacher's role.

In the interactive elements of games theme, the researcher found categories that describe the components of a digital game that could have influenced learning effectiveness. These categories include feedback and rewards, goals and rules, challenges, narratives, scenarios, characters, levels, self-monitoring features, audiovisual elements, adaptivity, competition, and usability.

Games can be effective in instruction because they have the potential to provide constant, timely, and constructive feedback that sometimes is lacking in instruction (Voerman, Meijer, Korthagen, & Simons, 2012). In addition, the presence of a clear goal, mission, or quest is a part of active and self-directed learning, which can motivate students and enhance their learning. Furthermore, the presence of challenges in games and overcoming them can be considered enough evidence of effectiveness in learning and they can also be considered a type of assessment that prepare learners to complete other formal assessments or measurement instruments (Hamari et al., 2016).

The use of narrative has also been effective in influencing the learning and engagement in students, as found in other studies (Quintero Johnson & Sangalang, 2017). Besides narrative, scenarios and characters can help teachers enhance the learning experience of students (Vusić, Bernik, & Geček, 2018). This happens by connecting knowledge in the classroom to common situations that learners might be familiar with, as well as by developing a sense of relatability between the learner and the game. All of this can translate into authentic and meaningful learning. Results from this integrative review can also encourage teachers to adopt some of the audiovisual elements of games such as the use of attractive and advanced graphics (Cheng et al., 2017) or narrated storylines (Muehrer et al., 2012) to enhance learning in their students and to make their instruction more engaging and appealing to students.

In addition, based on the findings of this integrative review, it can be argued that dividing content in logical sequences and connecting them to specific learning objectives and outcomes might help learners have a better focus and develop metacognition (Voerman, et al., 2012). Learners can be aware as they move from one level to the other, that they are making progress in their learning and they can even have evidence of that. One of the challenges of instruction is not having frequent opportunities for students to demonstrate mastery or not dividing in a logical sequence complex portions of learning, which can be solved through the use of levels with specific outcomes and assessments.

An important interactive feature of the games in this integrative review was the presence of self-monitoring features, which contribute to self-directed learning. Self-directed learning gives ownership to the student, making learning meaningful and relevant, which is a possible factor of effectiveness in these K-12 DGBL studies (Uz and Uzun, 2018). On the other hand, the adaptivity of games can help teachers diagnose the performance of the learners and it can also

help the learners with their metacognition and self-directed learning. Adaptive games provide a form of feedback that helps students to recognize when they are not making satisfactory progress. For these reasons, adaptivity of games is beneficial for learning (Plass, Homer, Pawar, Brenner, & MacNamara, 2019).

The findings of this study in terms of competition in games are aligned with studies of other instructional technologies, such as elearning, that have found competition to be an effective and influential factor in learning, as it increases learning motivation and improves performance (Worm & Buch, 2014). Teachers can find strategies to implement competition elements in their instruction to leverage the benefits of this game characteristic.

In terms of usability, findings of this review point out that learning effectiveness is influenced by the experience that learners have with the technology, especially when it is positive due to usability. When students have a positive attitude and experience satisfaction, they can be expected to have a better attitude toward learning in general (Knörzer, Brünken, & Park, 2016). This should be a special consideration for teachers and researchers looking to adopt digital learning games or any other instructional technology in the classroom.

Even though there are many benefits to active learning due to the ownership and involvement it gives to the learner, research has demonstrated that sometimes its implementation in instruction can be challenging (Brigati, England, & Schussler, 2019). DGBL can help teachers overcome this issue since games offer students an opportunity to adopt and practice several active learning strategies while they are playing.

As part of the active learning theme, the researcher found problem-solving and completion of tasks, as well as the collaboration and role-playing that students participated in could be identified as possible influential factors in learning. As an active learning strategy,

problem-solving and completing tasks can translate into more effective learning because it keeps the learner engaged and motivated (Hamari et al., 2016). In the case of role-playing, it has been very effective, especially in comparison to passive instructional strategies such as lecturing (Delnavaz et al., 2018). For these reasons, it can be argued that the digital games can be linked to effectiveness in learning.

Similarly, the application of sound instructional design principles could have enhanced learning in the interventions included in this integrative review. As research has demonstrated, effective and well-implemented instructional design principles can make learning effective and long-lasting (Hultberg, Calonge, & Lee, 2018). The instructional design principles found in the studies for this review include analysis, use of learning/instructional design theories and models, alignment with subject matter, external learning activities and materials, embedded assessments, and scaffolding.

The use of instructional analysis, theories, and models can impact learning because the the game design and study designs would be based on research on cognition and instructional design. Effective instructional design cannot rely on just one strategy or the simple use of a technology (Hultberg et al., 2018). For this reason, it is possible to argue that other instructional activities and materials made available in the classroom external to the game could have influenced the effectiveness of learning.

Having digital game-based instruction embedded in a system that includes other instructional activities and resources can be a strong and sound strategy to make learning effective; however, it is likely the holistic approach might influence learning rather than one element of it such as a game. The fact that the design of some of the games in this review were aligned with government or organizational standards can be strongly connected with learning

effectiveness because students get to practice with the game for assessments and milestones that later they are required to pass or complete. Similarly, embedding traditional assessments into a game can have an impact on learning since learners might not even feel they are testing, which can reduce their feelings of anxiety towards a subject matter (Huang et al., 2014). In addition, this strategy might be an opportunity for learners to practice before taking other external assessments, such as paper tests, or before being measured with other instruments for research purposes.

On the other hand, the learner and the teacher also played a substantial role in these studies, which might have contributed to learning effectiveness. Several studies in instructional design and technology have demonstrated that, more than the technology, the characteristics and background of the learner can play a role in effectiveness (Nakayama, Mutsuura, & Yamamoto, 2014). Moreover, learner's attitudes, beliefs, and emotions can also play a role in their learning, especially when a technology is involved (Knörzer et al., 2016).

In the studies of this integrative review, the learner's prior experience with the subject matter and with the game, and their attitudes towards games and the content were identified as possible influential factors in instruction. These characteristics and positive attitudes can translate into an effective learning experience for students when playing games or using any other instructional technology (Zhao, 2015).

Similarly, the role that teachers assume such as being involved in the design of the game or becoming facilitators or influencers could also have helped students become more effective. Having someone as familiar with the subject matter and class dynamics as the teacher is beneficial to the effectiveness of learning because students are already familiar with working

with the teacher and the teacher is knowledgeable of the specific resources that students need to experience success (Chang et al., 2012).

The goal of the fourth and last research question *"What areas or issues in K-12 DGBL still need to be studied in order to contribute to its effectiveness and advancement of the field?"* was to provide suggestions for future research, based on problems or gap found in the studies for this review. Very few studies focused on other independent variables, besides the game, and their relationship with effectiveness. Whereas factors such as gender did not play a role, other factors such as prior knowledge, motivation, and network speed did have an impact on learning (Suh et al., 2010). Even though it was not officially analyzed, some researchers acknowledged in some of these studies that other factors, such as problem-solving and novelty of technology, could have impacted learning (Hsiao, Chang, Lin, & Hu, 2014; Hwang et al., 2012). These findings demonstrate the importance of analyzing factors, beyond the technology, when studying learning effectiveness.

In addition, there is a need to avoid media comparison studies and focus on DGBL research designs that are more sound for instructional design and technology, such as design-based research, longitudinal studies, and more qualitative studies. This recommendation is aligned with claims made by other researchers in the field (Reeves, 1993; Surry & Ensminger, 2011; Warnick & Burbules, 2007). Furthermore, this integrative review identified the need for focusing on diverse populations, such as students with special needs, when implementing K-12 DGBL.

Implications for Practice

The results of this study can be beneficial for three type of practitioners: teachers, researchers, and administrators. Each one of them play a relevant role in student's learning and are strongly involved in decisions made in the classroom.

This study informs teachers about the areas in which DGBL has been effective and the outcomes of this intervention. This includes the types of variables that have actually been studied and if any of the features they want to implement have empirical proof of effectiveness. In addition, teachers can identify if DGBL can be suitable to change certain behaviors in their students and the types of instruments that can be used to assess change. Furthermore, the findings of this study can inform teachers about the elements that should be found in a digital learning game to make learning effective.

Many DGBL studies have focused on the perceptions and acceptance of teachers towards digital games (Bourgonjon et al., 2013), and however beneficial, teachers can find more value in a study that focuses on how has the effectiveness of digital learning games been measured with students. These results can be used in DGBL guides that are part of professional development for teachers or as part of DGBL implementation programs. Even though the findings of this study have focused on DGBL, some findings from this integrative review can be applied to any type of technology implemented in K-12 settings. For instance, the conceptual classification presented in Figure 5 can be a resource for teachers to think systematically about the implementation of instructional technologies. With this, teachers can identify the role they need to assume, the need to choose a technology that fosters active learning and that has interactive elements, and how the characteristics and attitudes of the learners play a role in the adoption of an instructional technology.

Moreover, the application of instructional design principles and how they played a role in effective learning experiences is an important implication for teachers, for they should not rely only on a technology to make learning engaging and effective. Technologies need to be implemented following instructional design principles. Also, assessment is still a fundamental part of learning, even in games, as this study found. Teachers also still need to have external activities and materials and not assume that resources embedded in the game are enough for learning. Also, when choosing a technology, teachers should evaluate if such technology is going to foster active learning and prompt students to engage in collaborative and problem-solving activities. The active learning connections to digital learning games not only contributed to engagement, but also to effectiveness of the overall learning experience (Annetta et al., 2009).

By looking at the elements found within digital games, it is possible to argue that there is value in non-digital and traditional games as well. Many of the game elements found in the studies of this review can be implemented in classrooms with low or no technology, such as competition, challenges, and rewards. Non-digital games and traditional games also have the potential to engage learners and contribute to knowledge acquisition as demonstrated by other studies (Nicholson, 2018; Sardone & Devlin-Scherer, 2016). This integrative review provides strategies that can be used by teachers with limited or no access to digital games and provides evidence that spending time playing games could be effective, if they are properly aligned with the content and if there is fostering of active learning. Table 11 provides examples of elements that can be used by teachers when considering non-digital and traditional games or when considering adopting some of game elements that require low or no technology.

On the other hand, most of the studies presented in this review had a collaborative relationship between teachers and the researchers. In many instances, researchers provided all of

the resources to implement DGBL, which might allow teachers with limited instructional resources to benefit from the affordances of digital learning games. Interactive elements of games, active learning, and good instructional design principles can be used in many instances at no cost, as explored in these studies. Teachers who face limitations to adopt digital learning games in the classroom can use strategies such as feedback, scaffolding, role-playing, and problem-solving to engage students and enhance learning.

For researchers, this study can be relevant because it presents a summary of the empirical K-12 DGBL literature, which gives them an idea of the gaps that need to be filled in order to advance this area. The wide variety of studies from different journals, disciplines, and years in this integrative review gives an ample perspective of K-12 DGBL. In addition, the data saturation process that was achieved during the data search and analysis of the study ensures that findings in this study are representative of the K-12 DGBL literature.

Researchers can be more conscious of the types of variables that have been studied and the instruments and research designs that were used for this purpose. Also, findings may assist researchers in identifying geographical areas where DGBL needs to be implemented and design potential strategies to improve education in places where it is needed. For instance, in this study, Africa and Latin America were not represented as places where DGBL is used.

Furthermore, this study identifies common problems when conducting empirical studies that they could avoid not only in DGBL, but in other areas as well. Some of these flaws include having short interventions or small populations, not having reliable or valid instruments, not providing detailed information about instruments, or not defining or contextualizing the variables. Findings of this integrative review can be a professional development tool for researchers, especially novice researchers, because they can identify flaws that they should avoid

when designing their studies. Even though the focus was digital games, these flaws should be avoided in any research study, so findings from this review can be beneficial for the overall research community.

The findings of the studies in terms of factors and conditions that could be influencing learning in DGBL and other information presented in the research agenda open several research opportunities for researchers interested in learning and instructional design. The findings of this integrative review can initiate a formal study of a framework for gamification, since the conceptual classification presented in Figure 5 includes gamification elements. Also, findings from this study can help researchers see DGBL as a systematic process, in which many factors and variables are responsible for outcomes and not just the technology.

Taking into account the research problems identified in the studies of this review, as well as the factors or conditions that might have influenced effectiveness, sound K-12 DGBL studies can be carried out by researchers. For instance, researchers should have a clear definition and contextualization of variables, as well as specific information about the game that was used during the intervention. An instructional design or learning theory/model should always guide these studies and research decisions should be made based on them. Moreover, researchers should provide research questions and thorough procedures for data collection and analysis, as well as information about the reliability and validity of their instruments. It is also beneficial to provide as much information about the instruments, so other researchers can use similar instruments or customize existing ones to complete their studies. Furthermore, the size of populations should be large enough to be able to generalize results and interventions should be lengthy enough to provide enough time for participants to learn how to play the game and apply or transfer knowledge. In addition, media comparison studies should always be avoided. Instead,

researchers should focus on the study of possible influential factors and how their presence or absence has an impact on effectiveness. For example, using Table 11, researchers might conduct research studies in which a comparison of games with and without these elements is carried out to study effectiveness. Finally, researchers should be transparent and specify the limitations of their studies.

Administrators are usually the stakeholders responsible for decisions. In many instances, they need empirical information to allow the adoption of technologies and instructional trends. The findings of this study can help administrators to consider DGBL as a feasible trend to enhance learning due to its several benefits, but also to take into account that successful implementation does not rely only on the game, but on other factors such as teacher's professional development, technology support, alignment with subject matter, and adequate research designs to effectively measure interventions.

Limitations of the Methodology

One limitation of the integrative review methodology can be its unified and integrated nature. Data analysis and the presentation of results should be carried out in a way that includes all of the articles selected for review (Whittemore & Knafl, 2005). Since a diversity of methodologies were included in this study for review, data analysis that was only pertaining to certain methodologies could not be conducted. Future studies can focus on one type of methodology (i.e. quantitative or qualitative) to study in detail their particular characteristics.

Another limitation of integrative reviews is the constant changes that databases go through. In addition, academic institutions change subscriptions to journals and databases on a regular basis, which produces different results when browsing articles, depending on the time of

the year. For this reason, it is not possible to ensure that the same sample and amount of articles can be yielded in each search due to these variations.

In addition, it is important to keep in mind that any type of review, including integrative reviews can be affected by embargoes. In library science, an embargo is a process in which the most recent studies are not available to subscribers until a certain period of time has passed (Barreau, Bouton, Renard, & Fournier, 2018). This ensures that subscribers do not cancel their memberships once they have obtained the most recent material. For this reason, it is possible that reviews do not include the latest publications.

Finally, another limitation of this integrative review is the focus on a specific population and environment. For this study, only K-12 populations and face-to-face environments were included. Results from this study might not be applicable to other populations, such as higher education or corporate environments, or to online or hybrid learning environments. However, those conclusions cannot be made without further research.

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APPENDIX A

Articles Used to Conduct Integrative Literature Review

Author(s)	Year	Article Name	Journal
Adisti, A.	2016	Creating an English Computer Game as an Interactive Material in Teaching English To Young Learner (TEYL)	Register Journal
Anderson & Barnett	2013	Learning Physics with Digital Game Simulations in Middle School Science	Journal of Science Education & Technology
Annetta, Minogue, Holmes, & Cheng	2009	Investigating the Impact of Video Games on High School Students' Engagement and Learning about Genetics	Computers & Education
Anyaegbu, Ting, & Li	2012	Serious Game Motivation In An EFL Classroom in Chinese Primary School	The Turkish Online Journal of Educational Technology
Beserra et al.	2014	Practising Arithmetic Using Educational Video Games with an Interpersonal Computer	Educational Technology & Society
Brom, Sisler, & Slavik	2010	Implementing Digital Game-Based Learning in schools: Augmented learning environment of 'Europe 2045'	Multimedia Systems
Bunch, Robinson, Edwards, & Antonenko	2014	How a Serious Digital Game Affected Students' Animal Science and Mathematical Competence in Agricultural Education	Journal of Agricultural Education
Cankaya & Karamete	2009	The effects of educational computer games on students' attitudes towards mathematics course and educational computer games	Procedia - Social & Behavioral Science
Chang, Wu, Weng, Sung	2012	Embedding game-based problem-solving phase into problem-posing system for mathematics learning	Computers & Education

Chee & Tan	2012	Becoming Chemists through Game-based Inquiry Learning: The Case of Legends of Alkhimia	Electronic Journal of E-Learning
Chen & Lee	2018	Application-driven Educational Game to Assist Young Children in Learning English Vocabulary	Educational Technology & Society
Chen, Liao, Cheng, Yeh, & Chang	2012	Influence of Game Quests on Pupils' Enjoyment and Goal-pursuing in Math Learning	Educational Technology & Society
Chen, Liu, & Shou	2018	How Competition in a Game-based Science Learning Environment Influences Students' Learning Achievement, Flow Experience, and Learning Behavioral Patterns	Journal of Educational Technology & Society
Chen, Wang, Lin	2015	The Comparison of Solitary and Collaborative Modes of Game-based Learning on Students' Science Learning and Motivation	Educational Technology & Society
Chen, Wong, & Wang	2013	Effects of type of exploratory strategy and prior knowledge on middle school students' learning of chemical formulas from a 3D role-playing game	Educational Technology Research & Development
Cheng et al.	2017	Is immersion of any value? Whether, and to what extent, game immersion experience during serious gaming affects science learning	British Journal of Educational Technology
Cheng, Lou, Kuo, & Shih	2013	Investigating elementary school students' technology acceptance by applying digital game-based learning to environmental education	Australasian Journal of Educational Technology
Choi, Y.	2014	Effectiveness of game based learning to minimize boolean functions	Multimedia Tools & Applications
Chu & Chang	2014	Developing an educational computer game for migratory bird identification based on a two-tier test approach	Educational Technology Research & Development
Costu, Aidin, & Filiz	2009	Students' conceptions about browser-game-based learning in mathematics education: TTNetvitamin case	Procedia - Social & Behavioral Science
Cutumisu, Blair, Chin, & Schwartz	2015	Posterlet: A Game-Based Assessment of Children's Choices to Seek Feedback and to Revise	Journal of Learning Analytics

Dagnino, Ballauri, Benigno, Caponetto, & Pesenti	2013	Reasoning abilities in primary school: A pilot study on poor achievers vs. normal achievers in computer game tasks	Learning and Individual Differences
Denham, A.R.	2015	Supporting conceptual understanding of the associative and distributive properties through digital gameplay	Journal of Computer Assisted Learning
DiCerbo	2014	Game-Based Assessment of Persistence	Educational Technology & Society
Dorji, Panjaburee, & Srisawasdi	2015	A Learning Cycle Approach to Developing Educational Computer Game for Improving Students' Learning and Awareness in Electric Energy Consumption and Conservation	Educational Technology & Society
Dourda, Bratitsis, Griva, & Papadoloupou	2014	Content and Language Integrated Learning through an online Game in Primary School: A case study	Electronic Journal of E-Learning
Eseryel, Ge, Ifenthaler, & Law	2011	Dynamic Modeling As A Cognitive Regulation Scaffold for Developing Complex Problem-solving Skills In An Educational Massively Multiplayer Online Game Environment	Educational Computing Research
Eseryel, Law, Ifenthaler, Ge, & Miller	2014	An Investigation of the Interrelationships between Motivation, Engagement, and Complex Problem Solving in Game-based Learning	Educational Technology & Society
Hawlitschek & Köppen	2014	Analyzing Player Behavior in Digital Game-Based Learning: Advantages and Challenges	Proceedings of European Conference on Game-based Learning
Hsiao & Chen	2016	Using a gesture interactive game-based learning approach to improve preschool children's learning performance and motor skills	Computers & Education
Hsiao, Chang, Lin, & Hu	2014	Development of children's creativity and manual skills within digital game-based learning environment	Journal of Computer Assisted Learning
Hsiao, Chang, Lin, Chang, & Chen	2014	The influence of collaborative learning games within different	Australasian Journal of Educational Technology

		devices on student's learning performance and behaviours	
Huang, Huang, & Wu	2014	Embedding diagnostic mechanisms in a digital game for learning mathematics	Educational Technology Research & Development
Hung, Huang, & Hwang	2014	Effects of digital game-based learning on students' self-efficacy, motivation, anxiety, and achievements in learning mathematics	Journal of Computers in Education
Hung, Kuo, Sun, & Yu	2014	An Interactive Game Approach for Improving Students' Learning Performance in Multi-Touch Game-Based Learning	IEEE Transactions on Learning Technologies
Hwang, Chiu, & Chen	2015	A contextual game-based learning approach to improving students' inquiry-based learning performance in social studies courses	Computers & Education
Hwang, Hsu, Lai, & Hsueh	2017	Interaction of problem-based gaming and learning anxiety in language students' English listening performance and progressive behavioral patterns	Computers & Education
Hwang, Sung, Hung, Huang, & Tsai	2012	Development of a personalized educational computer game based on students' learning styles	Educational Technology Research & Development
Hwang, Wu, & Chen	2012	An online game approach for improving students' learning performance in web-based problem-solving activities	Computers & Education
Hwang, Yang, & Wang	2013	A concept map-embedded educational computer game for improving students' learning performance in natural science courses	Computers & Education
Ke & Abras	2013	Games for engaged learning of middle school children with special learning needs	British Journal of Educational Technology
Kebritchi, Hirumi, & Bai	2010	The effects of modern mathematics computer games on mathematics achievement and class motivation	Computers & Education
Ku, Chen, Wu, Lao, & Chan	2014	The Effects of Game-Based Learning on Mathematical Confidence and Performance: High Ability vs. Low Ability	Educational Technology & Society

Lin et al.	2013	Game-Based Remedial Instruction in Mastery Learning for Upper-Primary School Students	Educational Technology & Society
Liu, Rosenblum, Horton, & Kang	2014	Designing Science Learning with Game-Based Approaches	Computers in the Schools
Lucht & Heidig	2013	Applying HOPSCOTCH as an exer-learning game in English lessons: two exploratory studies	Educational Technology Research & Development
Mat Zin & Mohamed Masrop	2010	User Interface and Interaction Design Based on a Motivation Model for Digital Game-Based Jawi Learning Software	Design Principles and Practices
Mavridis, Katmada, & Tsiatsos	2017	Impact of online flexible games on students' attitude towards mathematics	Educational Technology Research & Development
Meluso, Zheng, Spires, & Lester	2012	Enhancing 5th graders' science content knowledge and self-efficacy through game-based learning	Computers & Education
Miller, Robertson, Hudson, & Shimi	2012	Signature Pedagogy in Early Years Education: A Role for COTS Game-Based Learning	Computers in the Schools
Muehrer, Jenson, Friedberg, & Husain	2012	Challenges and opportunities: using a science-based video game in secondary school settings	Cultural Studies of Science Education
Ott & Pozzi	2012	Digital games as creativity enablers for children	Behavior & Information Technology
Panoutsopoulos & Sampson	2010	Integrating Digital Games Into School Curriculum: A Field Experiment In Math Education	Proceedings of International Conference on Cognition and Exploratory Learning in Digital Age
Panoutsopoulos & Sampson	2012	A Study on Exploiting Commercial Digital Games into School Context	Educational Technology & Society
Papastergiou, M.	2009	Digital Game-Based Learning in high school Computer Science education: Impact on educational effectiveness and student motivation	Computers & Education

Petros & Georgios	2011	Educational Applications of Serious Games: The Case of the Game Food Force in Primary Education Students	Proceedings of European Conference on Game-based Learning
Razak & Connolly	2013	Using Games for Learning, From the Students' Perspectives	Proceedings of European Conference on Game-based Learning
Schaaf, R.	2012	Does Digital Game-based Learning Improve Student Time-on-task Behavior And Engagement In Comparison To Alternative Instructional Strategies?	Canadian Journal of Action Research
Schifter, Ketelhut, & Nelson	2012	Presence and Middle School Students' Participation in a Virtual Game Environment to Assess Science Inquiry	Educationa Technology & Society
Shah & Foster	2014	Undertaking an Ecological Approach to Advance Game-Based Learning: A Case Study	Educational Technology & Society
Simpson & Clem	2008	Video Games in the Middle School Classroom	Middle School Journal
Singaravelu	2008	Video game-based learning in English Grammar	Journal of Educational Technology
Suh, Kim, & Kim	2010	Effectiveness of MMORPG-based instruction in elementary English education in Korea	Journal of Computer Assisted Learning
Sung & Hwang	2013	A collaborative game-based learning approach to improving students' learning performance in science courses	Computers & Education
Sung, Hwang, & Yen	2015	Development of a contextual decision-making game for improving students' learning performance in a health education course	Computers & Education
Tsai, F.	2016	The Effectiveness Evaluation among Different Player-Matching Mechanisms in a Multi-Player Quiz Game	Educational Technology & Society
Warren, Dondlinger, Stein, & Barab	2009	Educational Game as Supplemental Learning Tool: Benefits, Challenges, and Tensions Arising from Use in an Elementary School Classroom	Journal of Interactive Learning Research

Wu, Chen, & Huang	2014	Using digital board games for genuine communication in EFL classrooms	Educational Technology Research & Development
Yang, Y.	2012	Building virtual cities, inspiring intelligent citizens: Digital games for developing students' problem solving and learning motivation	Computers & Education
Yang, Y.	2015	Virtual CEOs: A blended approach to digital gaming for enhancing higher order thinking and academic achievement among vocational high school students	Computers & Education
Yien, Hung, Hwang, &Lin	2011	A game-based learning approach to improving students' learning achievements in a nutrition course	The Turkish Online Journal of Educational Technology
Young & Wang	2014	The Game Embedded CALL System to Facilitate English Vocabulary Acquisition and Pronunciation	Journal of Educational Technology & Society

APPENDIX B

Summary of Research Question #1

Author(s)	Year	Variables	Research Design	Instruments	Was DGBL effective?
Adisti, A.	2016	content knowledge	research and development	pre/post-test, observations, questionnaire, interview	yes
Anderson & Barnett	2013	content knowledge	experimental	Pre/post-test, interviews, observations	yes
Annetta, Minogue, Holmes, & Cheng	2009	engagement, content knowledge	quasi experimental	post-test, observation protocol	only for engagement
Anyaegbu, Ting, & Li	2012	motivation, factors that influence game effectiveness	experimental	observations, field notes, interviews, literature review	yes
Beserra, Nussbaum, Zeni, Rodriguez, & Wurman	2014	learning, attitudes towards math	quasi experimental	pre/post-test, questionnaires, observations, data from the game	yes
Brom, Sisler, & Slavik	2010	acceptance	case study	pre/post-tests, video surveillance and field notes, and in-depth interviews	yes
Bunch, Robinson, Edwards, & Antonenko	2014	achievement	quasi experimental	pre/post-test	no
Cankaya & Karamete	2009	attitudes towards math, attitudes towards computer games	survey methodology	pre/post-survey	no
Chang, Wu, Weng, Sung	2012	problem solving ability, flow	quasi experimental	pre/post-test	yes
Chee & Tan	2012	knowledge, perceptions, epistomological	experimental	pre/post-survey	yes

		beliefs, classroom culture			
Chen & Lee	2018	performance, flow, self-regulation, behavior	quasi experimental	pre/post-test	yes
Chen, Liao, Cheng, Yeh, & Chang	2012	perception of enjoyment, goal orientation, goal intensity	quasi experimental	questionnaire	yes
Chen, Liu, & Shou	2018	learning achievement, flow, learning behavioral patterns	quasi experimental	pre/post-test, survey, behavioral logs	yes
Chen, Wang, Lin	2015	science learning, motivation	experimental	pre/post-test, survey, interviews	yes
Chen, Wong, & Wang	2013	performance, motivation	quasi experimental	test, questionnaire	yes
Cheng et al.	2017	learning, degree of game immersion	quasi experimental	pre/post-test	yes
Cheng, Lou, Kuo, & Shih	2013	acceptance of DGBL	case study	survey, interviews	yes
Choi, Y.	2014	learning achievement, learning attitude	experimental	pre/post-test, questionnaire	yes
Chu & Chang	2014	motivation, achievement, technology acceptance	quasi experimental	pre/post-test, questionnaires	yes
Costu, Aidin, & Filiz	2009	attitudes towards Math	case study	interviews	yes
Cutumisu, Blair, Chin, & Schwartz	2015	choices to seek negative feedback and to revise	not specified	post-test	yes
Dagnino, Ballauri, Benigno,	2013	logical reasoning, school achievement	not specified	questionnaire, observation	yes

Caponetto, & Pesenti					
Denham, A.R.	2015	understanding of content, attitudes toward games	quasi experimental	pre/post-test, survey	only for understanding of content
DiCerbo	2014	task persistence	not specified	game log files	yes, it provided evidence of effectiveness for assessment models
Dorji, Panjaburee, & Srisawasdi	2015	learning achievement, awareness, satisfaction	experimental	pre/post-test, pre/post-questionnaire, questionnaire	yes
Dourda, Bratitsis, Griva, & Papadoloupou	2014	geography knowledge, English vocabulary, reading skills, the use of foreign language learning strategies, collaboration, satisfaction with the game	case study	questionnaires, pre/post-test, observation, journals, video-recording, and evaluation tasks	yes
Eseryel, Ge, Ifenthaler, & Law	2011	problem-solving skills	experimental	pre/post-test, observation, focus group	no
Eseryel, Law, Ifenthaler, Ge, & Miller	2014	engagement, motivation, problem solving outcomes	experimental	pre/post-test, motivation inventory, confidence scale	yes
Hawlitschek & Köppen	2014	learning performance, learning motivation	experimental	pre/post-test, questionnaire	no
Hsiao & Chen	2016	learning performance, motor skills	quasi experimental	pre/post-test	yes
Hsiao, Chang, Lin, & Hu	2014	creativity, manual skills	quasi experimental	pre/post-test, questionnaire	yes

Hsiao, Chang, Lin, Chang, & Chen	2014	learning performance, memory retention	quasi experimental	pre/post-test, observations	yes
Huang, Huang, & Wu	2014	learning motivation, learning confidence	experimental	pre/post-test, questionnaire, interviews	yes
Hung, Huang, & Hwang	2014	self-efficacy, motivation, achievement, anxiety	quasi experimental	pre/post-test, questionnaire, interviews	only for self-efficacy, motivation, and achievement
Hung, Kuo, Sun, & Yu	2014	learning performance, learning satisfaction	experimental	pre/post-test, questionnaire	yes
Hwang, Chiu, & Chen	2015	learning achievement, learning motivation, satisfaction degree, flow state.	quasi experimental	pre/post-test, pre/post questionnaires, interviews	yes
Hwang, Hsu, Lai, & Hsueh	2017	achievement, motivation, English anxiety	quasi experimental	pre/post-test. questionnaire for motivation, questionnaire for English anxiety	yes
Hwang, Sung, Hung, Huang, & Tsai	2012	learning achievement, learning motivation	experimental	pre/post-test, questionnaire	yes
Hwang, Wu, & Chen	2012	knowledge, learning attitude, learning attitudes, flow, technology acceptance	experimental	pre/post-test, pre/post questionnaire	yes
Hwang, Yang, & Wang	2013	learning achievement, learning motivation, decrease of	quasi experimental	pre/post-test, questionnaire	yes

		cognitive load, acceptance			
Ke & Abras	2013	engagement, learning	case study	in-field observation, artifact analysis, school performance report, pre/post-test	yes
Kebritchi, Hirumi, & Bai	2010	achievement, motivation	experimental	demographic survey, motivation survey, pre/post-test, interviews	only for achievement
Ku, Chen, Wu, Lao, & Chan	2014	confidence towards Math, achievement	experimental	pre/post-test, questionnaire	yes
Lin et al.	2013	mastery learning	experimental	pre/post test	yes
Liu, Rosenblum, Horton, & Kang	2014	Science knowledge test score	not specified	pre/post-test, questionnaire	yes
Lucht & Heidig	2013	factual knowledge, attitudes towards English	exploratory	log-files, questionnaire, test	only for attitudes towards English
Mat Zin & Mohamed Masrop	2010	motivation	experimental	pre/post motivation survey, observations	yes when measured with pre/post test, not when measured through observations
Mavridis, Katmada, & Tsiatsos	2017	attitudes, effectiveness	experimental	pre/post-test, interviews	yes
Meluso, Zheng, Spires, & Lester	2012	self-efficacy, content knowledge	experimental	pre/post-test, questionnaire	yes
Miller, Robertson, Hudson, & Shimi	2012	social aspects of classroom life, personal aspects of children's development, learning	case study	observation, samples of children's written work, survey, interview, baseline tasks,	yes

				conversations, video and audio recordings, teaching artifacts	
Muehrer, Jenson, Friedberg, & Husain	2012	engagement, content understanding	not specified	pre/post test, observation, informal interviews, audio–video recordings, game metrics	yes
Ott & Pozzi	2012	creativity, attitude	experimental	direct observations	yes
Panoutsopoulos & Sampson	2010	achievement based on Greek Education standards, achievement based on general education standards, attitudes towards Math	experimental	pre/post-survey, post-test, worksheet	only for achievement based on general education standards
Panoutsopoulos & Sampson	2012	effectiveness, attitudes	experimental	questionnaire, post-test, worksheet	only for achievement based on general education standards
Papastergiou	2009	content knowledge, motivation	experimental	pre/post-test, observations, feedback questionnaire	yes
Petros & Georgios	2011	knowledge construction, attitudes, engagement	case study	pre/post-test	only for attitudes and for engagement
Razak & Connolly	2013	attitudes toward using games, attitudes toward learning by playing games, attitudes toward learning by making games,	not specified	interviews, survey	yes

		attitudes toward learning using DGBL and non DGBL, attitudes toward school			
Schaaf	2012	engagement, time-on task behavior	experimental	observations, survey	neutral
Schifter, Ketelhut, & Nelson	2012	attitudes towards game, perceived presence	pre-experimental	pre/post survey, focus group	only one group demonstrated effectiveness
Shah & Foster	2014	factors to successfully implement DGBL systems thinking	case study	knowledge test, interviews, and participant and video observations.	yes
Simpson & Clem	2008	engagement, vocational standards	case study	journal, videotaped sessions	yes
Singaravelu	2008	performance in English Grammar	experimental	pre/post-test	yes
Suh, Kim, & Kim	2010	achievement	experimental	survey, tests	yes
Sung & Hwang	2013	learning attitudes, learning motivation, self-efficacy and learning achievements.	experimental	pre/post-test, questionnaire for measuring the learning attitudes, motivation and self-efficacy, and the questionnaire for surveying the cognitive load	yes
Sung, Hwang, & Yen	2015	learning motivation, learning achievement, flow experience	quasi experimental	pre/post-test, questionnaires, interviews	yes
Tsai	2016	knowledge acquisition, enjoyment perception, gaming behavior	experimental	pre/post-test	yes

Warren, Dondlinger, Stein, & Barab	2009	teacher time answering questions, motivation, achievement	case study	observations, interviews, video recording methods	yes
Wu, Chen, & Huang	2014	learning performance, motivation	experimental	pre/post-test, questionnaire, interview	yes
Yang	2012	problem solving, learning motivation, achievement	quasi experimental	pre/post-test, questionnaire, test	only for problem-solving and learning motivation
Yang	2015	creative skills, problem solving skills, critical thinking, academic achievement	quasi experimental	pre/post-test	yes
Yien, Hung, Hwang, &Lin	2011	nutrition education	quasi experimental	test	yes
Young & Wang	2014	English learning, perception of game	experimental	pre/post-test, observations, questionnaire, delayed test, interviews	neutral

APPENDIX C

Coding Dictionary - Possible Influential Factors in K-12 DGBL

Code/Category	Example	Theme	Authors
Adaptivity	"The level of difficulty will increase automatically based on player's mastery in Jawi reading and game skills."	Interactive elements of games	Mat Zin & Masrop, 2010
	"As learners follow the guidance of the storyline and complete the missions, the contents increase."	Interactive elements of games	Suh et al., 2010
Alignment with subject matter	"the My-Pet-My-Quest system embeds math learning into a pet-nurturing game"	Application of instructional design principles	Chen et al., 2012
	"This game embedded scientific knowledge that is easy to remember"	Application of instructional design principles	Chen et al., 2015
Analysis	"I started conducting a need analysis by interviewing the English teacher. The questions were about the English material, method of teaching English, and also the result of English laerning during the teaching and learning process."	Application of instructional design principles	Adisti, 2016
	"will thus help drive inquiry instruction due in part because the teacher has the ability to use the common experiences of the students in the virtual environment as a foundation for probing deeper student understanding of the embedded content"	Application of instructional design principles	Annetta et al., 2009
Audiovisual elements	"There were three kinds of quizzes in the English computer game such as: mention the name of the animals, guess the sound of the animals, and click the picture of the animals based on the instruction"	Interactive elements of games	Adisti, 2016

	"The contextual gaming module presents the gaming contents based on the gaming materials (photos, images, video clips and text) stored in the learning materials database"	Interactive elements of games	Sung et al., 2015
Challenges	"By role-playing the hero who lost his or her pet, the player needs to navigate and go through a series of puzzle challenges to find and liberate the pet."	Interactive elements of games	Ke & Abras, 2013
	"The particular game consisted of nine different challenges, with various questions on arithmetic, algebraic and geometrical concepts"	Interactive elements of games	Mavridis et al., 2017
Collaboration	"When playing the game in small groups or pairs, children were listening to each other, providing support, demonstrating processes, and answering questions."	Active learning	Miller et al., 2012
	"students collaborate in order to test solutions within the virtual world of the game"	Active learning	Panoutsopoulos & Sampson, 2012
Competition	"When a game starts, a tic-tac-toe board is displayed on the computer screen and used by two competing players"	Interactive elements of games	Tsai, 2016
	"shows the structure of the game, which is a multiplayer competition board game"	Interactive elements of games	Hwang, Wu, & Chen, 2012
Embedded assessments	"As students play through the levels, a variety of assessment metrics are collected…"	Application of instructional design	Muehrer et al., 2012
	"Within each room, the student has to solve a number of problems which are presented to him/her in the form of true/false and multiple-choice questions"	Application of instructional design	Papastergiou, 2009
External learning activity and material	"educational computer game serving as supplementary material after a traditional lecture of abstract concepts of household electrical energy consumption and conservation."	Application of instructional design principles	Dorji et al., 2015

	"the teacher spent four lessons lecturing on electrical science in the classroom."	Application of instructional design principles	Hsiao, Chang, Lin, & Hu, 2014
Feedback	"Also, when completing a turn and waiting for their opponent's turn, the left side of the game screen will show the previous question, immediate feedback and elaborated feedback to show whether their answer is correct, and to offer clues relevant to the question for the player"	Interactive elements of games	Tsai, 2016
	"if the student passed a level with a few birds remaining, those birds were worth bonus points, whereas if the student failed to pass a particular level, he/she would not reach the next level."	Interactive elements of games	Hsiao, Chang, Lin, & Hu, 2014
Goals	"Additionally, a set of specific goals and rules were added to the game, since goals are motivating, and rules make playing both exciting and fair"	Interactive elements of games	Mavridis et al., 2017
	"Clear rules/goals"	Interactive elements of games	Cheng et al., 2017
Learner's attitudes	"Only 'perceived usefulness' had both indirect effects and direct effects on the learner's acceptance of DGBL"	Learner's characteristics and attitudes	Cheng et al., 2013
	"'I like this game because it had interesting content to learn and play.'"	Learner's characteristics and attitudes	Chen et al., 2015
Learner's familiarity with games	"Game tutorials, based on examples provided by the game publisher or created by the instructor, were assigned in order to ensure learner's familiarity with the games' functions and tasks and to avoid frustration."	Learner's characteristics and attitudes	Yang, 2015
	"Next, each student completed a 20-min, online Crystal Island tutorial in order to familiarize them with the controls and character movements within the gaming environment..."	Learner's characteristics and attitudes	Meluso et al., 2012

Learner's prior experience with subject matter	"All participants had taken classes on chemical elements and their properties, valence and chemical compounds"	Learner's characteristics and attitudes	Chen et al., 2014
	"In kindergarten level 1, children receive 40 min of computer coursework every week and each classroom is equipped with one whiteboard, one projector, two computers, and a large amount of e-learning content."	Learner's characteristics and attitudes	Hsiao & Chen, 2016
Levels	"These levels represented increasing levels of difficulty and contextual feedback for learning."	Interactive elements of games	Chen et al., 2015
	"The game is structured around six stations/levels (landmarks around the globe) in the form of missions, which comprise hypermedia learning material and relevant questions of progressive difficulty levels"	Interactive elements of games	Dourda et al., 2014
Narrative, scenarios, and characters	"One theoretical underpinning for Crystal Island is narrative-centered learning."	Interactive elements of games	Beluso et al., 2012
	"The background story is about the main character's life after having surgery. The player faces three gaming scenarios and makes correct decisions to recover following the storyline of the game"	Interactive elements of games	Sung et al., 2015
	"On the storytelling layer, players face various simulated scenarios and crises relating to key contemporary issues that unified Europe faces"	Interactive elements of games	Brom et al., 2010
Problem-solving and completing tasks	"Each unit contains three types of learning tasks: conceptual understanding, computational fluency, and problem solving."	Active learning	Chen et al., 2012
	"In each mission, the students have to solve a number of problems, presented to them as open-ended questions."	Active learning	Dourda et al., 2014

Rewards	"Additional rewards will be offered after accomplishing various tasks."	Interactive elements of games	Dourda et al., 2014
	"When the students correctly answer a question or play a mini-game in the set time, their personal gaming scores increase"	Interactive elements of games	Hwang, Wu, & Chen, 2012
Role-playing	"For instance, players navigate between a birds-eye view and a street-view of their amusement park as they become engaged in different sub-system activities such as building rides, hiring staff, managing finances, attending to the needs of the park visitors, and monitoring overall park activities."	Active learning	Shah & Foster, 2014
	"During the learning process, the students play the role of the king to find the target plants"	Active learning	Sung & Hwang, 2013
Scaffolding	"If the students fail to pass the tests, the fairy will give them some hints or illustrative examples."	Application of instructional design principles	Sung & Hwang, 2013
	"The computer-assisted instruction provides instructional boxes shown on the display containing suggested responses."	Application of instructional design principles	Wu et al., 2014
Self-monitoring features	"to enhance the student's awareness of regulated learning, the My-Pet-Shop system allows students to monitor their learning status via visualization tools"	Interactive elements of games	Chen & Lee, 2018
	"If the player believes that he/she can understand the content, they may stop the video at any time by clicking the "Stop Video Playing" button located on the right-hand side and clicking the 'Roll Dice' button to continue playing their game."	Interactive elements of games	Lin et al., 2013
Teacher as facilitator	"monitors students' activities with the game and provides support with regard to the implementation of the agreed plan of actions..."	Teacher's role	Panoutsopoulos & Sampson, 2012

	"They obtain feedback from their teacher and judge whether the solution is reasonable."	Teacher's role	Chang et al., 2012
Teacher as influencer	“The teacher’s acceptance of the computer game programs can easily motivate and influence the students”	Teacher’s role	Anyaegbu et al., 2012
	“The second most influential actors in the schools were the teachers: their attitudes towards the research and researchers, their preconceptions about how the students would engage with the game and the support that they offered throughout the play session.”	Teacher’s role	Muehrer et al., 2012
Teacher involved in game design	"Moreover, the content of the ToES was certified by two Nature and Science Technology teachers, and the difficulty level of each task was tested and verified by two experts with DGBL experience and ten sixth grade students who have studied electrical science."	Teacher's role	Hsiao, Chang, Lin, & Hu, 2014
	"the classroom teacher is the primary game author."	Teacher's role	Annetta et al., 2009
Usability	"it was intended that the user interface be simple and intuitive and that navigation be as easy as possible so that students easily find their way around, without the need of any particular written instructions or technical"	Interactive elements of games	Papastergiou, 2009
	"the interface was developed to be as simple and unobtrusive as possible to facilitate use of the video game and reduce unnecessary cognitive processing"	Interactive elements of games	Beserra et al., 2014
Use of learning and instructional design theories/models	"This study attempts to develop a personalized educational computer game based on the learning style theory."	Application of instructional design principles	Hwang, Sung et al., 2012

	"During the learning process, students were required to interpret information about the problem by constructing the problem space and actively manipulating and testing before triggering particular solution processes. According to information-processing theories, if appropriate schema cannot be activated, the solver goes back to an earlier stage and redefines the problem or uses another method to solve the problem, so called means-ends analysis"	Application of instructional design principles	Chen et al., 2018