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Entertainment video games for academic learning – a systematic review

Léa Martinez^a, Manuel Gimenes^a, and Eric Lambert^{*a}

^aUniversité de Poitiers, Centre de Recherches sur la Cognition et l'Apprentissage, France

*Corresponding author

Centre de Recherches sur la Cognition et l'Apprentissage (CeRCA)

Université de Poitiers

MSHS – Bâtiment A5

5, rue Théodore Lefebvre

86073 Poitiers Cedex 9

France

33 (0)5 49 45 47 13

eric.lambert@univ-poitiers.fr

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Léa Martinez is a PhD candidate in cognitive psychology at University of Poitiers. Her current research focuses on board games practice's effects on the development of cognitive functions and academic achievement.

Manuel Gimenes is an Associate Professor at the department of psychology at University of Poitiers. His research interests cover two topics: the role of memory in language processing, and the effect of gaming (video games and board games) on cognitive processing.

Eric Lambert is a Full Professor at the department of psychology at University of Poitiers. His research interests are literacy development of students with and without learning disabilities, with a focus on game-based methods (video games and board games).

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Abstract

Entertainment video games are very popular among young audiences. Nevertheless, despite their potential to improve cognitive functioning, they are still studied rarely as a tool for digital game-based learning. To better understand video gaming practices' value in the classroom, this article provides a systematic review of literature on the effect of entertainment video games on academic learning. Our literature search yielded 49 relevant intervention studies published between 2005 and 2019 that integrated entertainment video games into academic curricula from preschool to college. Our review revealed that entertainment video games can be an effective educational tool and are beneficial in almost all academic disciplines, particularly in foreign language and science. However, research on entertainment video gaming's effects on academic learning is still not extensive enough and remains mostly qualitative. Future studies need to provide a quantitative approach to complete and confirm already-existing literature, particularly in the environmental and social sciences, physical education, and programming. Given entertainment video games' popularity and benefits on cognition and learning, it seems essential to investigate their practical value further in the education sector and to determine the mechanisms that mediate their effects on academic learning.

Introduction

Today's learners are digital natives who require new teaching styles to foster their motivation and engagement in academic learning (Kiryakova et al., 2014). A recent challenge is the implementation of alternative, modern teaching methods in education curricula that are adapted to our cultural context. Digital game-based learning (DGBL) is one of these methods. Its main purpose is to increase students' interest and ensure their motivation to learn using digital media (Prensky, 2003). Indeed, students' positive attitude toward video games is viewed as a great opportunity to develop a stimulating and effective learning context (for a review, see Coleman & Money, 2020). However, not all types of video games have been studied to the same extent. Currently, DGBL mainly has been restricted to willingness to design appropriate educational video games, and most studies have focused on serious, non-entertainment video games that include pedagogical content during game play (for a review, see Zhonggen, 2019). Compared with conventional methods, serious games improve declarative knowledge, procedural knowledge, and knowledge retention (see Riopel et al., 2020, for a meta-analysis). Their use in classrooms enhances students' learning in many academic disciplines (Backlund & Hendrix, 2013). However, some studies have recommended using non-educational, entertainment video games – whose main goal is players' enjoyment – in academic learning methods, deeming them just as effective as serious games (Breuer & Bente, 2010; Charsky & Mims, 2008).

This interest in entertainment video games in the DGBL literature highlights the need to examine and discuss the value of non-serious video games in academic learning. As far as we know, no systematic review has been conducted on entertainment video games' value as pedagogical support. For ease of reading, considering that no agreement exists on a term for non-educational games (*commercial video games*, *Commercial-Off-The-Shelf video games*,

entertainment video games have been used, among others), we decided to use the term *entertainment video games* in this article.

From Serious Video Games to Entertainment Video Games in Academic Learning

For several years, serious video games have been studied extensively in various research fields. Contrary to entertainment video games, they play an increasingly important role in academic learning. *Serious games* can be defined as any digital games in which their pedagogical purpose is embedded in the game scenario (Klopfer et al., 2009). A wide variety of serious games (e.g. *Darfur is dying*, Ruiz, 2006; *Dragonbox*, Siew et al., 2016; see Zhonggen, 2019, for a meta-analysis) has been mostly developed and used in educational and learning contexts, offering a beneficial alternative to conventional instructional methods, as they correspond to a more active method that enables students to engage in higher-level cognitive tasks (Riopel et al., 2020). Playing serious games integrated into a school curriculum enhances academic learning in many disciplines (mathematics, history, English, etc.). Meta-analyses have found small to moderate positive effects of serious games on reading (Cheung & Slavin, 2012), vocabulary (Thompson & von Gillern, 2020), and natural sciences (Riopel et al., 2020). Moreover, students learn more through serious video games if they receive additional teaching materials. External supports such as additional instructions, exercises, and feedback are moderators of serious games' effects on academic learning (Sitzmann, 2011; Wouters et al., 2013). Thus, serious video games have become a common tool in educational settings, particularly for academic learning.

One issue in game and learning studies, particularly in the academic domain, is the lack of interest in all kinds of video games. A clear-cut distinction exists between serious and entertainment video games. Serious games designed for academic learning have been studied widely over the past decade, but they do not correspond to mainstream video games and are not commercialized, or they are commercialized to a limited audience. However,

entertainment video games are very popular, mainly among young audiences. They aim to entertain the players and have no direct pedagogical purpose. For a long time, entertainment video games have suffered from their bad reputation regarding child education. Many studies have highlighted violent entertainment video games' negative impact on behavior or affect (Anderson & Bushman, 2001; Medeiros et al., 2020). However, many other studies have focused on the overall benefits of playing entertainment video games on cognitive functions (for a review, see Choi et al., 2020). According to recent literature, the positive impact from playing entertainment video games on cognitive functions, particularly executive functions (McCord et al., 2020; Yang et al., 2020), largely has been demonstrated (for a review, see Choi et al., 2020). Executive functions are a set of mental processes necessary to control behavior in new and adapting situations (Diamond, 2013; Elliott, 2003). Compared with non-video gamers, entertainment video gamers demonstrate better attention, working memory, visuospatial, decision-making, and problem-solving abilities (Bediou et al., 2017; Buelow et al., 2015; Ruiz-Marquez et al., 2019). Furthermore, playing entertainment video game training programs has been found to improve attention, visuospatial (Oei & Patterson, 2013), working memory (Blacker et al., 2014), and problem-solving (Shute et al., 2015) abilities. For example, playing Call of Duty for 28 hours significantly increased visual working-memory performance. It seems that any entertainment video game genre (e.g., traditional video games, simulation video games, strategy video games, action video games, fantasy video games) has the potential to enhance cognitive functions (Choi et al., 2020), but action video games in particular were found to improve attention and spatial cognition (Bediou et al., 2017). Therefore, entertainment video games were found to enhance several cognitive and executive functions.

Numerous studies have demonstrated that cognitive and executive functions are related, positively and strongly, to academic learning. For example, cognitive abilities such as

executive functions, reasoning, and working memory are predictors of reading and mathematics skills (Peng & Kievit, 2020). Working memory training based on 20 training sessions with working memory tasks enhanced children's academic achievement in reading and mathematics (Studer-Luethi et al., 2016). Therefore, it is relevant to consider whether entertainment video gaming also could improve academic skills through enhancement of cognitive functions. Some studies have already found a positive correlation between entertainment video game practice and academic learning. Compared with non-video gamers, entertainment video gamers demonstrate better results in English foreign language (Sundqvist, 2019; Pitarch, 2018), reading, and mathematics (Bowers & Berland, 2013). Therefore, we believe that it is essential to establish an overview of the use of entertainment video gaming for academic learning to determine whether it could be an effective alternative learning method in educational settings, and to highlight its strengths and limitations. To do so, an integrative review was conducted to assess the literature on entertainment video game use in academic learning methods. We addressed the central questions of how entertainment video games influence academic learning, how such video games' effects are assessed in the education sector, and what recommendations can be made for future research. In this review, we focused on intervention studies in school settings so that we could determine the effect of entertainment video gaming on academic learning. Thus, intervention studies using entertainment video games that were integrated into a school curriculum (from preschool to college) were reviewed and classified according to the academic learning domain that they assessed.

This literature review is of both scientific and pedagogical interest because it provides insights for both the research and education fields. Currently, to our knowledge, no integrative review on entertainment video games and academic learning exists. DGBL literature reviews mainly focused on the use and effect of serious games in education (Coleman & Money,

2020; Riopel, 2019; Zhonggen, 2019) while entertainment video games literature reviews reported effects on cognitive functions and did not focus on education (Choi et al., 2020). Therefore, this article provides an overview of the recent literature on an original topic, along with scientific insights on entertainment video games' effects on academic learning and pedagogical insights on the implementation of this kind of video game in classrooms.

Method

The article selection method was based on recent/best practice guidelines describing the state of the art of conducting literature reviews (Siddaway et al., 2019).

Literature Search

The literature search was conducted through PsycINFO (APA science and psychology database), Web of Science (multiple science databases), and ERIC (education research database). Peer-reviewed journal articles written in English and published between 2005 (which corresponds to the release of Nintendo DS and Xbox 360 game systems) and 2019 were searched. The search request was [(“video game” OR “computer game”) AND (“academic learning” OR “learning” OR “classroom” OR “school” OR “education”) - (“serious game” OR “game-based learning” OR “game-based instruction” OR “computer-assisted instruction”)]. We excluded search terms that could lead to studies about educational games that are not within our search scope. The search yielded 3,677 articles. Based on their titles, 452 articles were identified as potentially relevant and were screened for inclusion.

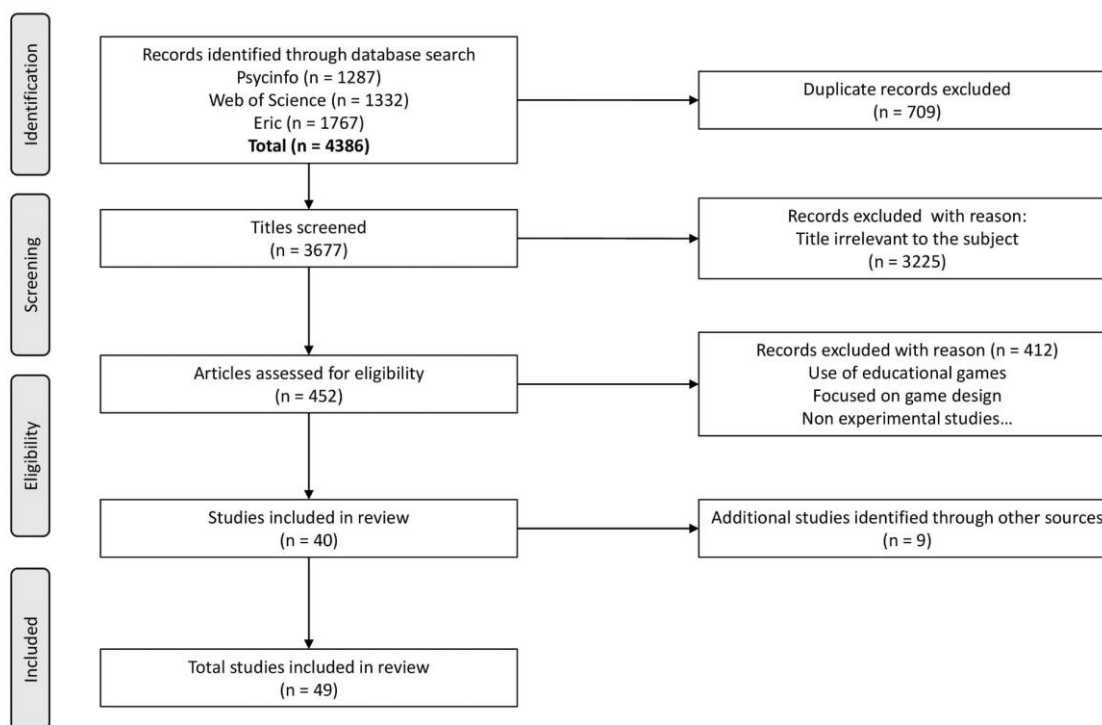
Inclusion Criteria

Studies were included if they were written in English, published in peer-reviewed journals, used entertainment video games in pedagogical contexts, and assessed participants' academic learning and related skills. Altogether, 40 articles met the inclusion criteria and were selected. Nine additional articles that met the criteria were found through other sources,

bringing the total to 49 articles selected for this review. An overview of the search and inclusion process is provided in Figure 1.

Figure 1

Overview of the selection process Summary of Included Studies



For each selected article, the academic learning domain, video game used, type of statistical analyses, and main results were noted. The articles then were grouped according to the academic learning assessed. This review includes academic learning from preschool to university level.

Results

The results are organized by academic domains to assess the effect of video game use on each domain (Table 1).

Table 1*Selected articles*

Academic field	Discipline	Articles	School grade levels	Video games (category)	Number of participants	Type of analyses
Literature	Foreign language	Camacho Vásquez and Ovalle (2019)	College, undergraduates	Scribblenauts (puzzle-action game), Age of Empires II (real-time strategy game)	15	Qualitative
		deHaan (2005)	College, unknown	Jiikyoo Pawafiru Puro Yakkyu 6 (Japanese baseball game)	1	Qualitative
		Newgarden and Zheng (2016)	College, undergraduates	World of Warcraft (massively multiplayer online role-playing game)	5	Qualitative
		Wu (2019)	College, unknown	Pokemon Go (mobile augmented reality game)	61	Quantitative
		Vahdat and Rasti Behbahani (2013)	College, undergraduates	Runaway: A Road Adventure (point & click adventure game)	40	Quantitative
		Ebrahimzadeh (2017)	High school, unknown	Warcraft III: The Frozen Throne (real time strategy game)	241	Quantitative
		Ebrahimzadeh and Alavi (2016)	High school, unknown	Warcraft III: The Frozen Throne (real time strategy game)	136	Quantitative
		deHaan et al. (2010)	College, undergraduates	Parappa the Rapper 2 (rhythm game)	80	Quantitative

		Miller and Hegelheimer (2006)	College, unknown	The Sims (life simulation game)	18	Quantitative
		Chen and Yang (2013)	College, undergraduates	Bone (adventure game)	22	Quantitative
		Ranalli (2008)	College, unknown	The Sims (life simulation game)	9	Quantitative
		Janebi Enayat and Haghghatpasand (2017)	College, undergraduates	The Secret of Monkey Island (adventure game)	30	Quantitative
	Native language	Berger and McDougall (2013)	High school, college, 12 th grade and undergraduates	L.A. Noire (adventure and puzzle game)	Unknown	Qualitative
		Marlatt (2018)	High school, 12 th grade	Minecraft (adventure sandbox game)	16	Qualitative
		Lacasa et al. (2008)	Elementary school, 3 rd grade	Tomb Raider (adventure game)	21	Qualitative
		Franceschini et al. (2013)	Elementary school, unknown	Rayman Raving Rabbids (mini party games)	20	Quantitative
		Franceschini et al. (2017)	Elementary school, unknown	Rayman Raving Rabbids (mini party games)	28	Quantitative
Sciences	Mathematics	O'Rourke et al. (2017)	Elementary school, 3 rd and 4 th grades	Dr. Kawashima's Brain Training (puzzle game)	236	Quantitative
		Miller and Roberston (2011)	Elementary school, 3 rd and 4 th grades	Dr. Kawashima's Brain Training (puzzle game)	634	Quantitative

	Stansbury et al. (2014)	College, undergraduates	Wii Play Motion (mini party games)	111	Quantitative
	Lamb (2013)	Middle school, unknown	Angry Birds (puzzle and artillery game)	Unknown	Qualitative
	Novak and Tassell (2015)	College, undergraduates	Unreal Tournament 2004 (first person shooter), Angry Birds (puzzle and artillery game)	30	Quantitative
Physics	Herodotou (2018)	Preschool, pre- kindergarten	Angry Birds (puzzle and artillery game)	32	Quantitative
	Sun et al. (2015)	High school, 9 th grade	Angry Birds Space (puzzle and artillery game), Cut the Rope (puzzle game)	83	Quantitative
	de Aldama and Pozo (2019)	High school, unknown	Angry Birds Space (puzzle and artillery game)	110	Quantitative
	Masson et al. (2011)	Middle school, unknown	Enigmo (puzzle game), Railroad Tycoon 3 (management, strategy game)	51	Quantitative
	Jurcevic (2008)	College, unknown	Scorched 3D (artillery game)	Unknown	Qualitative
	Nordine (2011)	High school, unknown	Super Mario Bros. (platform game)	Unknown	Qualitative

	Biology and environmental science	Hobbs et al. (2019)	Preschool to high school, pre-kindergarten to 12 th grade	Minecraft (adventure sandbox game)	>500	Qualitative
		Herrero et al. (2014)	High school, 10 th grade	Spore (simulation, management game)	22	Qualitative
	Scientific methods and thinking	Stansbury and Munro (2013)	College, undergraduates	Dance Dance Revolution (exergame)	65	Quantitative
		Monjelat et al. (2012)	High school, 9 th grade	SimCity Creator (city-builder game) e)	10	Qualitative
		Shah and Foster (2014)	Middle school, 5 th and 6 th grades	RollerCoaster Tycoon 3 (simulation, management game)	21	Quantitative
		Checa-Romero and Pascual Gómez (2018)	Middle school, 7 th grade	Minecraft (adventure sandbox gam	85	Quantitative
Humanities and social sciences	History	Lee and Probert (2010)	High school, 11 th grade	Civilization (turn-based strategy game)	12	Qualitative
		Squire and Barab (2004)	High school, 9 th grade	Civilization (turn-based strategy game)	18	Qualitative
		Pagnotti and Russell (2012)	High school, 9 th grade	Civilization (turn-based strategy game)	Unknown	Qualitative
		Charsky and Ressler (2011)	High school, 9 th grade	Civilization (turn-based strategy game)	82	Quantitative

		Craft (2016)	High school, unknown	Minecraft (adventure sandbox game)	49	Qualitative
		Gilbert (2019)	High school, 9 th to 12 th grade	Assassin's Creed (adventure game)	14	Qualitative
Geography		Kim and Shin (2016)	College, undergraduates	SimCity (simulation, management game)	33	Qualitative
Economy		Sierra (2019)	College, unknown	SimCity (simulation management game)	136	Qualitative
		Foster (2011)	Middle school, 4 th to 6 th grade	RollerCoaster Tycoon 3 (simulation, management game)	26	Quantitative
		Krom (2012)	College, unknown	FarmVille (simulation game)	75	Quantitative
Physical education	Sport knowledge	Jenny and Schary (2014)	College, unkown	Madden NFL (U.S. football game)	40	Quantitative
		Jenny et al. (2017)	College, undergraduates and graduates	Don Bradman Cricket 14 (cricket game)	89	Quantitative
Physical activity		Nyberg and Meckbach (2017)	Elementary to high school, unknown	Just Dance (exergame)	>20, 4 for analyses	Qualitative
		Gibbs et al. (2017)	High school, unknown	Just Dance (exergame)	25	Qualitative
		Finco et al. (2015)	Elementary and middle school, unknown	Xbox-Kinect exergames	24	Qualitative

Literature

The largest body of research in this review demonstrated the benefits from using video games for foreign language learning, with most studies indicating significant improvements in students' foreign language vocabulary through the use of video games. One qualitative study found that playing *Scribblenauts* and *Age of Empires II* increased English vocabulary acquisition among Colombian college students (Camacho Vásquez & Ovalle, 2019). Furthermore, deHaan (2005) also observed that playing a Japanese baseball video game improved a U.S. student's Japanese oral and written comprehension skills. The student identified several learning supports from the game, including repetition of actions and sentences; contextual clues, such as expected baseball movements; and simultaneous presentation of oral and written language. Newgarden and Zheng (2016) also analyzed interactions between students from various nations playing *World of Warcraft* and noticed that the game could improve English learning because students' communicative activities sometimes corresponded with advanced English proficiency levels. These first three studies used a qualitative method to assess foreign language learning, without any control group nor inferential statistical analyses. Five studies compared the use of video games with traditional learning methods for vocabulary acquisition. The first study detected improvement in English learning attitudes and achievement among Taiwanese students who played *Pokemon Go* (Wu, 2019). Iranian students who played the adventure game *Runaway: A Road Adventure* outperformed students who took a traditional class on English vocabulary learning (Vahdat & Rasti Behbahani, 2013). Ebrahimzadeh (2017) also demonstrated that, compared with an intensive reading method, Iranian students who played *Warcraft* and those who only watched the game gained significantly in English vocabulary levels. Interestingly, comparisons between players and watchers of video games yielded mixed results. With *Warcraft*,

Ebrahimzadeh et al. (2016, 2017) found no differences between players and watchers on vocabulary acquisition, but deHaan et al. (2010) found that Japanese students who played a rhythm game were outperformed by those who only watched the game. One reason may involve game interactivity, which creates an additional cognitive load and diverts players' attention away from learning vocabulary. Three other studies compared the effect of supplementary activities added to video games on vocabulary learning. First, students from various language backgrounds who received explicit vocabulary and grammar activities before playing *The Sims* scored significantly higher on vocabulary and grammar questionnaires than students with optional access to an online dictionary during the game and students without additional activities or resources (Miller & Hegelheimer, 2006). However, Chen and Yang (2013) demonstrated that Taiwanese students who were allowed to take notes while playing the adventure game *Bone* did not outperform those who only played the game, with both groups improving their vocabulary learning to the same extent. Thus, the benefits from supplementary activities elicited mixed results, but it seems that students have a favorable attitude toward these added materials for their learning and view them as important while playing the game (Ranalli, 2008). In most studies, students have expressed positive perceptions toward video game use for foreign language learning, viewing such games as helpful and an additional motivation, particularly for vocabulary learning (Janebi Enayat & Haghighatpasand, 2017).

Several studies also employed video games for literature learning. The use of *L.A. Noire* allowed college students to link the game experience to other novels they already studied (Berger & McDougall, 2013). The students mentioned that the game corresponded to a digital novel that caught their interest and positively changed their approach to literature. The famous video game *Minecraft* also was used with high school students to reproduce scenes from a novel in the game (Marlatt, 2018). The teacher noticed that students felt more

engaged through the game and had a deeper understanding of the novel. Likewise, Lacasa et al. (2008) used the game Tomb Raider in a primary school as a theme for theater scene writing and production. Children demonstrated better oral and written skills, along with better critical thinking abilities. It seems that video games can function as an efficient tool for literature classes, positively impacting students' engagement and critical thinking. However, future studies need to assess whether video games significantly benefit students' literacy skills. Two studies have examined the effect of action and non-action video games on reading performance in dyslexic children (Franceschini et al., 2013, 2017). The speed and accuracy of children's reading significantly increased after playing action Rayman Raving Rabbids mini-games, but not non-action mini-games. Further studies will be needed to understand how action video game use can improve reading skills acquisition, but these two studies already demonstrated that improvement in attention abilities due to action video gaming can explain enhancements in reading proficiency directly.

Sciences

Several studies have found that playing video games have a positive impact on learning mathematics. Two studies have examined this effect using the game Dr. Kawashima's Brain Training. The first study compared use of the game with a traditional learning method with 10-year-old students learning mathematical operations (O'Rourke et al. 2017). The group that played Dr. Kawashima's Brain Training experienced significant improvement in both speed and accuracy in their mathematical calculations compared with the control group, which used traditional learning. Moreover, the interviews during the intervention period indicated increasing motivation to learn mathematics. Using the same game, Miller and Robertson (2011) reported significant gains in children's mental computation skills from using the game compared with a control group that attended traditional classes. These two studies were based on a relatively large sample (236 and 634

students, respectively). More complex mathematical concepts also can be improved by playing video games. Stansbury et al. (2014) found improvement in undergraduate students' statistics knowledge from playing Wii Play Motion mini-games. The concepts of parabolas and vectors also can be learned more quickly by playing Angry Birds (Lamb, 2013). The benefits from learning mathematics by playing video games need to be examined further in future research, but an early conclusion can be drawn because current research has indicated that playing action video games leads to improvements in the cognitive skills necessary to learn mathematics, such as working memory and spatial abilities (Novak & Tassel, 2015).

All the selected studies on teaching physics through video gaming focused on learning motion concepts. Three studies examined this through popular games such as Angry Birds. The first one assessed this game's effect on preschoolers' understanding of projectile motion (Herodotou, 2018). After playing the game, 5-year-old children demonstrated a significantly better understanding of projectile motion and were able to predict parabola movements correctly. Another study compared the use of Angry Birds Space and Cut the Rope with a traditional learning method among high school students (Sun et al., 2015). Students who played Angry Birds Space tended to improve their understanding of circular-motion concepts, while students who played Cut the Rope significantly improved their knowledge of pendulum concepts. The effect was significant, measured through the use of concept maps to assess students' learning, but not with multiple-choice exams. A third study found that using Angry Birds alone may not be sufficient to elicit significant learning of motion concepts. de Aldama and Pozo (2019) added a specific instructional method to the game, providing an epistemic goal for students by suggesting questions that they needed to answer while playing the game. Compared with the control group and the group that played the game without questions, participants with an epistemic goal demonstrated significant improvement in their understanding of motion concepts. Other types of games also can enhance the learning of

motion concepts. With Enigmo, an arcade-style game, Masson et al. (2011) found a gain in students' problem-solving skills related to object motion. Finally, two qualitative studies that evaluated learning about projectile motion through play highlighted students' positive reactions. Jurcevic (2008) observed that college students who played the artillery game Scorched 3D discovered physics concepts about angles and speeds through the game on their own. Students then reported having fun using this game in physics class. Likewise, it seems that most of the students were highly motivated and strongly engaged in learning projectile motion concepts through Super Mario Bros. (Nordine, 2011). However, the teacher noticed that students who were uncomfortable with problem-solving in informal settings experienced some frustration, probably because they were not accustomed to open-ended problems and needed a more clearly defined approach for their learning.

Fewer studies focused on learning biology and environmental sciences through the use of video games. Only two qualitative studies were identified in this domain. Hobbs et al. (2019) set up the Science Hunters Project using Minecraft. Students of all ages were invited to solve specific problems in the game to explore science topics and gain knowledge about natural and environmental science subjects, such as volcanoes, animal habitats, flowers, and biomes. The teachers who implemented this project in class noticed improvement in students' learning and understanding of these various themes. Students were motivated to play the game and learn about science through the game. Moreover, teachers noted that the project may encourage students to attend college. The second study assessed the game Spore as a learning tool in high school biology class (Herrero et al., 2014). Students had to decide whether the theories of evolution represented in the game were in agreement with Darwin's evolution theory and natural selection concepts. Students applied their academic knowledge in the game experience and sharpened their understanding of biological evolution concepts. The positive effect would come from playing the game, but only if it were combined with

interactions with the teacher or other students. Thus, Spore seems to be a good tool for fostering students' interest and biology learning through interactive way. Despite their promising results, these two qualitative studies are insufficient to confirm a significant positive effect of video game use on natural science learning. Thus, this benefit needs to be confirmed in future quantitative studies.

Besides academic knowledge in science, video games also can be used to develop scientific methods and thinking. For example, Stansbury and Munro (2013) used the Wii game Dance Dance Revolution to teach factorial designs to undergraduate psychology students. Students used the dance scores to learn and implement mixed factorial designs. Compared with students who received a traditional lecture, those who played the game significantly improved their performance on a factorial design knowledge questionnaire. Even more generally, video games can be used to develop scientific thinking and creativity. For example, SimCity Creator seems to be a solid tool for developing students' problem-solving skills (Monjelat et al., 2012). By playing this game, the students created a representation of in-game problems and solved it using different strategies. Likewise, playing RollerCoaster Tycoon 3 significantly increased middle school students' systems thinking knowledge (Shah & Foster, 2014). Regarding the development of students' creativity, Checa-Romero and Pascual Gómez (2018) found that students scored significantly higher on a creativity test after building the house of their dreams in Minecraft.

Therefore, these findings highlight the benefits of playing video games for students' scientific skills, but further quantitative studies need to confirm these benefits as they relate to problem-solving processes, logical thinking, and creativity.

Humanities and Social Sciences

Most studies on the benefits of video games on learning history focused on the use of the game Civilization in high school. Lee and Probert (2010) observed that this game helped

reinforce U.S. history concepts on wars, military alliances, politics, and geography. However, the teacher was concerned that the students remained relatively passive and did not participate often during the lesson. Squire and Barab (2004) also observed that Civilization aided learning of world history and geography facts and definitions, but that students' engagement depended on their perception of the game's value for learning. Many students felt that the game was complex and that its relevance to history lessons was not clear enough. Thus, not all students understood its value for learning history. Likewise, Pagnotti and Russel (2012) found that even though students were motivated and comfortable with the game, they were unsure of its usefulness in learning history. To enhance Civilization's educational value, Charsky and Ressler (2011) asked students to use or create concept maps while playing the game. However, with this addition, students' attention, motivation, satisfaction, and positive perception of the game significantly decreased during the game session. Further studies with a quantitative research design are needed to assess Civilization's actual benefits on learning history and whether it is an appropriate game in an educational context. Indeed, other video games can be used during history lessons. Craft (2016) used Minecraft to teach high school students about ancient Rome's history. After building Roman temples in a 3D model of Rome, students scored higher grades on history and Latin assessments. Assassin's Creed also seems to be a good tool for history lessons, especially considering that this game offers a mode dedicated to history learning – the "Discovery Tour" (Gilbert, 2019). Students who played the game had a more critical perspective on history, could reconsider their preconceptions of historical facts, and could discuss the game's historical accuracy. Once again, further quantitative studies will be needed to confirm the benefits from playing these video games on learning history, and the most appropriate conditions for using this tool need to be specified in particular.

Very few studies specifically have investigated learning geographical concepts. Only one qualitative study found that college students who played SimCity seemed to enhance their understanding of urban geography theories (Kim & Shin, 2016). Moreover, interviews revealed that students were motivated to learn new skills through the game, critically assessed their in-game work, compared the game logic to real-world contexts, and experienced development in their geographic creativity through the game. Management simulations such as SimCity also are used for social studies and economics learning. Sierra (2019) noticed that playing SimCity helps students understand how public sector interventions work. Students also improved their time management, critical thinking, and problem-solving skills. Likewise, Foster (2011) found that students who played RollerCoaster Tycoon 3 scored significantly higher on economics and social studies knowledge questionnaires. The students who played FarmVille had a better mean score on their managerial accounting final exam than those who attended a traditional lecture, but this benefit was statistically not significant (Krom, 2012). All these findings indicate that students seem to benefit from certain video games in geography, social sciences, and economics learning. However, more studies need to be conducted to confirm this benefit.

Physical Education

Several studies indicated that playing video games can be beneficial for physical education. Two studies examined sports knowledge and found that, compared with a control group, college students who played a U.S. football video game (Jenny & Schary, 2014) or a cricket video game (Jenny et al., 2017) scored higher on sports knowledge questionnaires (rules, terminology, positions, etc.) and were interested in watching and playing U.S. football or playing cricket. Two other studies demonstrated how exergames (physical exercise video games) help to teach physical education. The famous exergame Just Dance appears to be a good tool to teach dance. Nyberg and Meckbach (2017) observed that students from

elementary school learned several dance movements effectively through this game. Students discerned the different aspects of movements that they learned. Gibbs et al. (2017) also observed that Just Dance helps high school students learn dance moves and develop their ability to create new movements and choreography. Exergames also seem to be good tools for students' motivation in physical education classes. Finco et al. (2015) used Xbox-Kinect exergames only with elementary and middle school students who were unmotivated to participate in physical education classes. Compared with a traditional lesson, the games stimulated students' motivation and interest, as the students engaged much more freely in physical activities. Moreover, teachers noticed that exergaming improved students' social skills, as they seemed less introverted and more collaborative with and supportive of each other.

Discussion

This integrative review was conducted to assess the literature on entertainment video game use in academic learning methods. Following Siddaway et al.'s (2019) guidelines, the literature search yielded 49 articles published between 2005 and 2019, spanning almost all academic fields. The analysis of these articles provides scientific and pedagogical insights on the implementation of entertainment video games in school settings and their effects on academic learning.

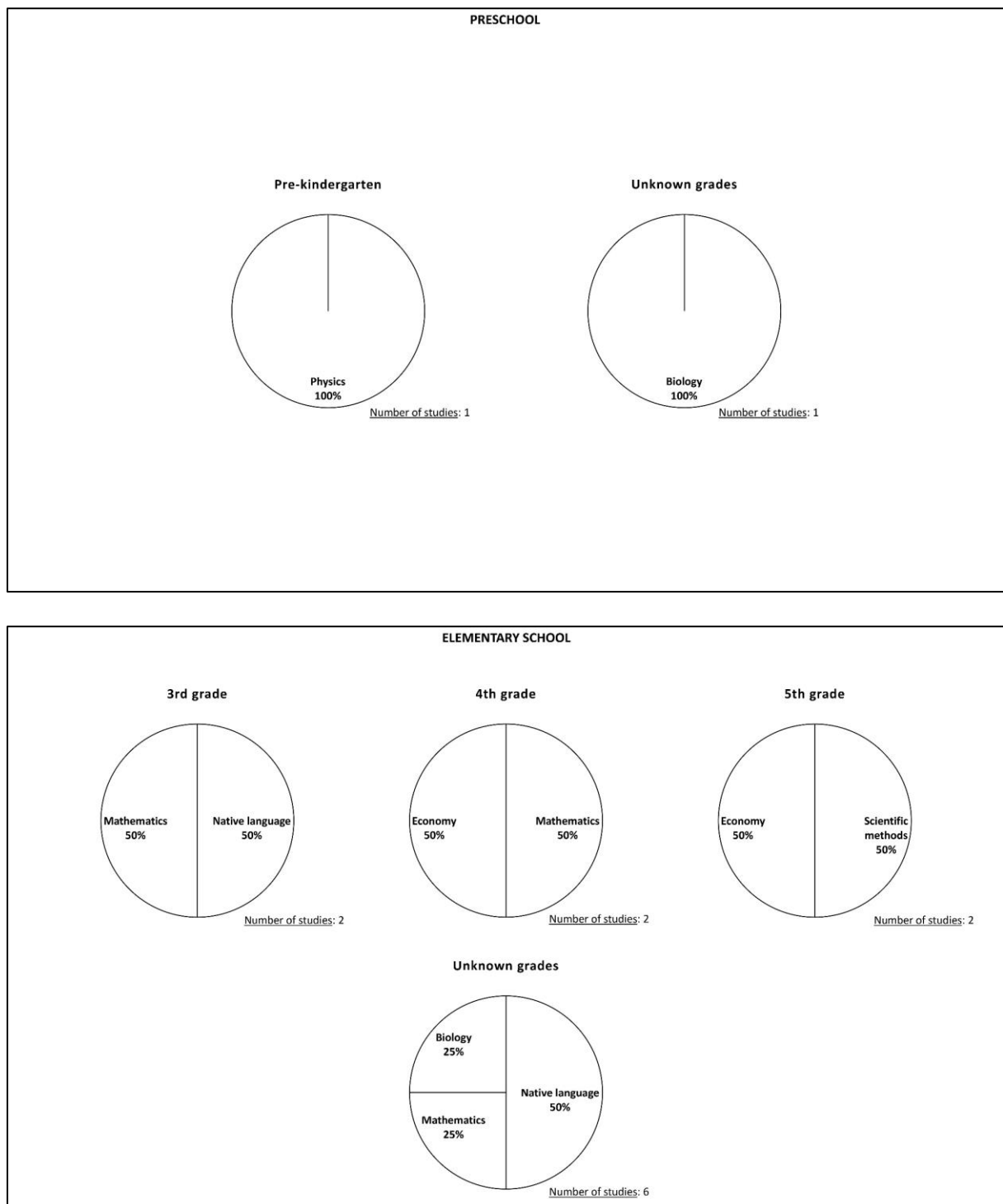
First, the literature indicates that the use of entertainment video games for academic learning represents a recent and dynamic field (83.7% of the selected articles were published after 2010). Entertainment video games can be implemented effectively in academic curricula across all grades, from preschool to college, and are beneficial in almost all academic disciplines. Promising results have been reported particularly in the literature and science disciplines (foreign language and mathematics learning, Ebrahimzadeh, 2017; Stansbury et al., 2014). However, mixed results were found for history (Charsky & Ressler, 2011).

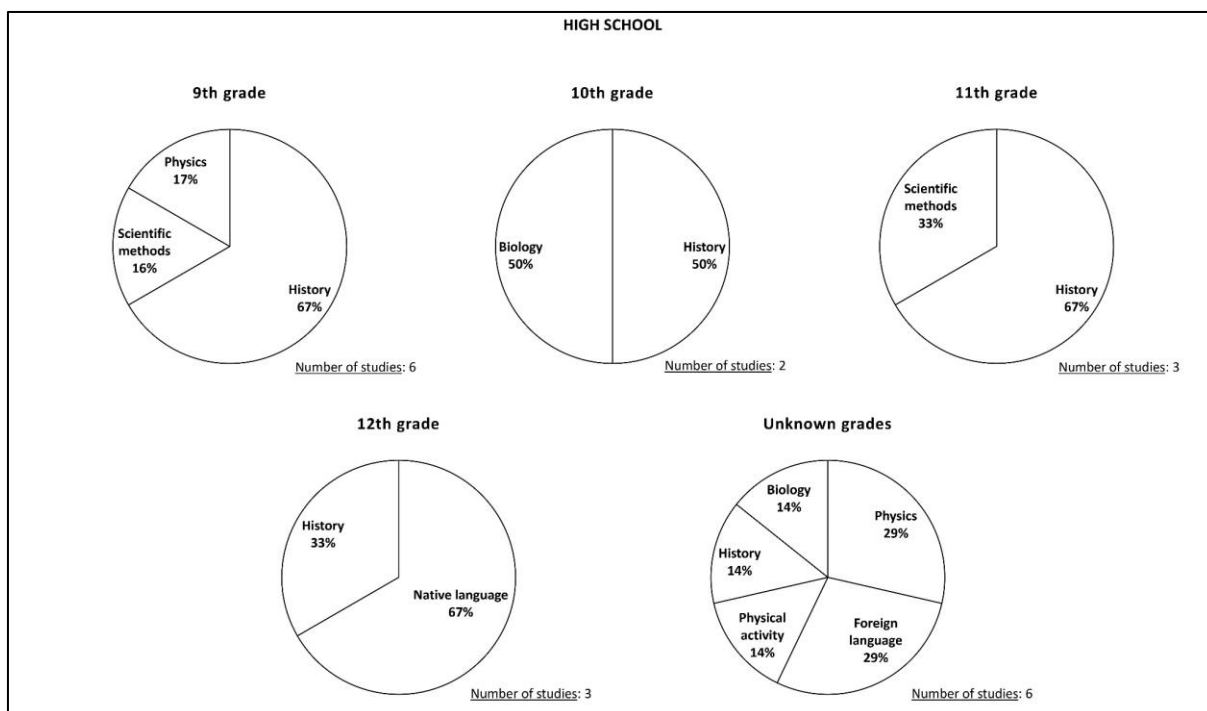
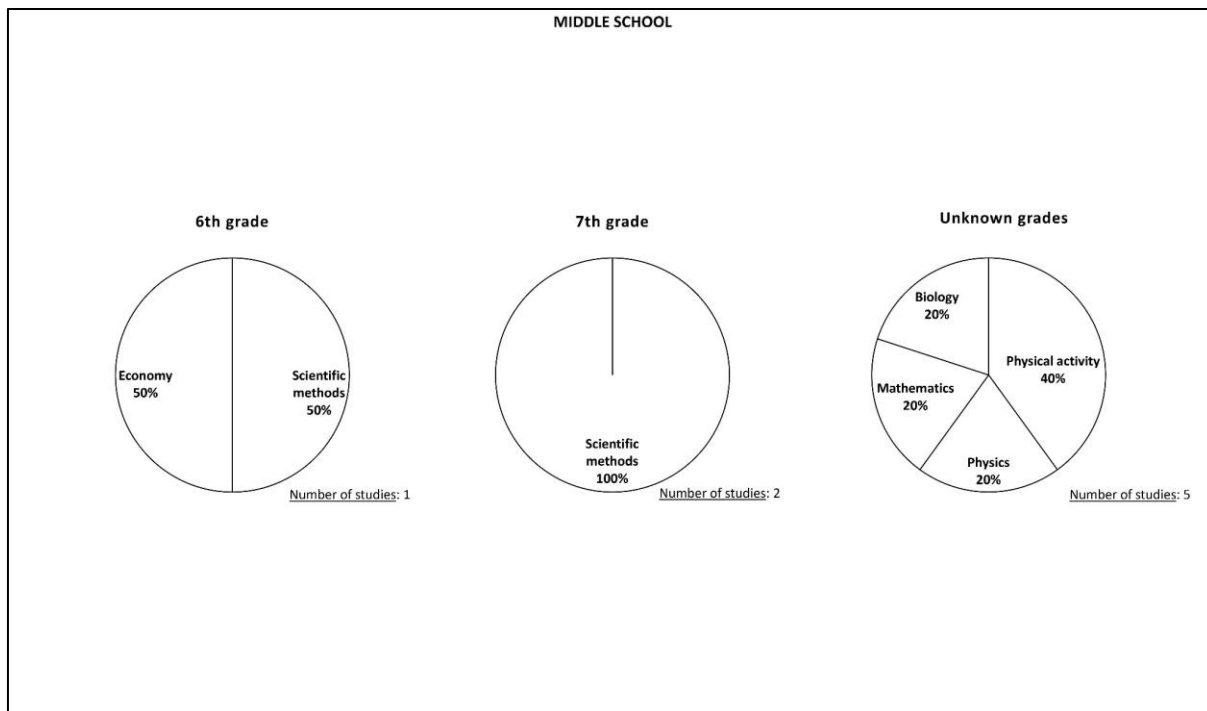
Students did not understand a video game-based method's relevance in history class when its usefulness is better perceived for other disciplines (Squire & Barab, 2004; Pagnotti & Russel, 2012). All the selected studies on entertainment video games and learning history took a qualitative approach; thus, further quantitative studies are needed to define the necessary conditions to improve history learning significantly through entertainment video games.

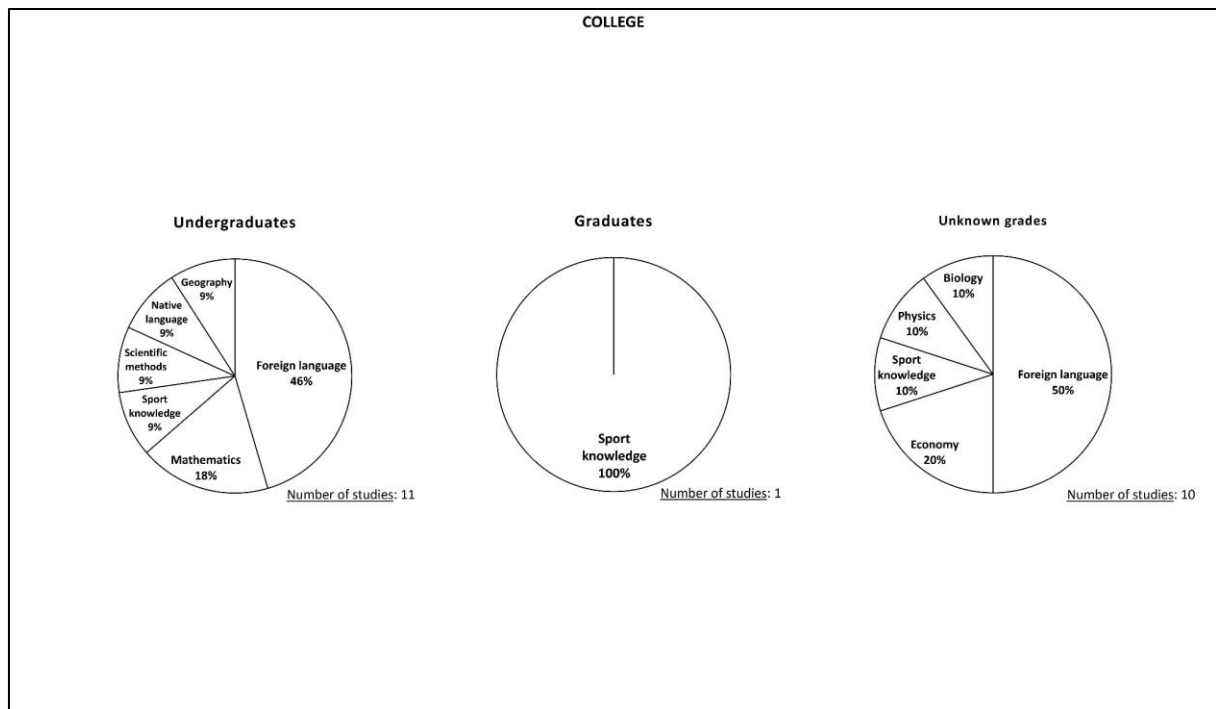
An overview of the studies' distribution by discipline and by school grade level is provided in Figure 2. Most selected articles focused on college students (38.8%), which is probably because video games' acceptability in education is higher for college students than for younger students. The same bias is found in studies investigating video games' cognitive benefits, which have focused mainly on college students (for a review, see Bediou et al., 2018). However, younger students from middle and high school already are regular video gamers (Ofli & Yalcin, 2019). Therefore, future studies need to assess whether video games are beneficial for students of all ages and in all academic domains, especially domains that are currently absent from the scientific field, such as art, technology, and engineering.

Figure 2

Selected articles' distribution by disciplines and by school grade levels.







It should be noted that not all academic fields have been studied to the same extent. Foreign language learning is the most widely studied discipline, with 25% of selected articles examining the acquisition of a second language. Indeed, the current trend of playing online video games allows for interactions between players worldwide and can be viewed as an efficient and playful way to practice a foreign language with native speakers. In comparison, only one study focused on geographical learning (Kim & Shin, 2016), and only two studies examined natural and environmental sciences (Hobbs et al., 2019; Herrero et al., 2014). Also, some disciplines – such as engineering, technology, and arts – mostly have been studied through game design (Coller & Scott, 2009; Doerschuk et al., 2013). Developing and designing a video game in class enhances programming and creativity skills, but playing already-existing games also seems useful for teaching programming or developing artistic creativity. For example, Minecraft is a good tool for developing students' creativity and programming skills, and it is accessible even to younger students (Overby & Jones, 2015; Wilkinson et al., 2013). Therefore, further studies are needed in several academic domains –

including history, geography, environmental and natural sciences, programming, and arts – and need to confirm and complete already-existing literature on these disciplines.

L'une des limites de cet revue systématique est l'absence de certaines disciplines, telles que l'ingénierie, la technologie et les arts, qui ont surtout étudiés à travers le game design.

Almost all selected articles reported significant benefits from entertainment video games on academic learning, but the experimental approach to studying entertainment video games' effects on academic learning remains mostly qualitative. School settings are ecological environments that allow for applied research in class, but limit experimental control. Control groups and comparisons with a traditional learning method often are missing. Half the selected articles are based on qualitative assessments of academic learning and did not compare their DGBL methods to a traditional learning method, or did not perform pretest and posttest learning measures. Although teachers and researchers' observations can be very relevant, a real need exists for studies with a quantitative approach to confirm and complete qualitative observations, particularly for literature, natural and environmental sciences, history, geography, and economics. Moreover, it should be noted that all articles were selected in peer-reviewed scientific journals and were more likely to be published as they report meaningful results about entertainment video games' benefits on academic learning. Articles focusing on understudied disciplines are highly needed to avoid publication bias. Further investigation of entertainment video games' practical value and application in classrooms would improve research quality in this field. Future studies are needed to systematically compare video game use in class with a traditional lecture to determine the precise benefit of video games on academic learning.

A final issue to address is the mechanisms underlying entertainment video games' beneficial effects on academic learning. These mediators between video games and learning remain under-examined. The explanatory factor most often presented is students' motivation.

Indeed, DGBL (Digital Game-Based Learning) leads to stronger student motivation and, therefore, to better learning performances (Kim & Shin, 2016; Nordine, 2011; O'Rourke et al., 2017). However, aside from this motivational effect, other factors also can explain entertainment video games' benefits on academic learning. Indeed, entertainment video games have been proven to enhance cognitive functioning, particularly executive functioning (for a review, see Choi et al., 2020), and this literature review suggests that some of the video gaming benefits on academic learning can be attributed to improved cognitive functioning. Thus, another mechanism that explains entertainment video games' benefits on academic learning could be improvement of cognitive performance due to video gaming practices. Some studies already have demonstrated that improvements in working memory, spatial abilities, or attention skills as a result of entertainment video gaming can explain mathematics and reading improvement directly (Franceschini et al., 2013, 2017; Novak & Tassel, 2015). Thus, future studies need to identify cognitive functions that are most impacted by entertainment video games and related the most to academic learning. Moreover, very few studies on cognitive training's effect on academic learning exist, so it is also necessary to define whether entertainment video games integrated into a school curriculum can enhance students' cognitive functioning and whether this improvement predicts entertainment video games' benefits to academic learning.

Conclusion

Given the popularity and benefits from entertainment video games on cognition, we believed that it was essential to determine whether they could be an effective alternative learning method in educational settings. This review showed that entertainment video games are beneficial tools for academic learning and can be implemented effectively in almost all academic disciplines and for all grades. Today is a favorable era for the use of entertainment video games as tools in the classroom. Most schools have the technological means necessary

to implement a DGBL method in class. Moreover, the entertainment video game market offers a wide range of choices suitable for diverse academic learning objectives. Despite their benefits, entertainment video games are still used rarely in schools. Teachers, parents, and even students are not always convinced of their usefulness for learning. Future studies need to investigate and highlight entertainment video games' practical value in the education sector further, as well as provide a quantitative assessment of academic learning through video gaming and define what mechanisms mediate entertainment video gaming sessions' effects on academic learning in class. This type of research surely will increase video games' acceptability level in the school environment in the future.

References

- Anderson, C. A., & Bushman, B. J. (2001). Effects of violent video games on aggressive behavior, aggressive cognition, aggressive affect, physiological arousal, and prosocial behavior: a meta-analytic review of the scientific literature. *Psychological Science, 12*(5), 353-359.
<https://doi.org/10.1111/1467-9280.00366>
- Backlund, P., & Hendrix, M. (2013). Educational games - Are they worth the effort? A literature survey of the effectiveness of serious games. *2013 5th International Conference on Games and Virtual Worlds for Serious Applications (VS-GAMES)*, 1-8. <https://doi.org/10.1109/VS-GAMES.2013.6624226>
- Bediou, B., Adams, D. M., Mayer, R. E., Tipton, E., Green, C. S., & Bavelier, D. (2017). Meta-analysis of action video game impact on perceptual, attentional, and cognitive skills. *Psychological Bulletin, 144*(1), 77-110. <https://doi.org/10.1037/bul0000130>
- Berger, R., & McDougall, J. (2013). Reading videogames as (authorless) literature. *Literacy, 47*(3), 142-149. <https://doi.org/10.1111/lit.12004>
- Blacker, K. J., Curby, K. M., Klobusicky, E., & Chein, J. M. (2014). Effects of action video game training on visual working memory. *Journal of Experimental Psychology: Human Perception and Performance, 40*(5), 1992-2004. <https://doi.org/10.1037/a0037556>
- Bowers, A. J., & Berland, M. (2013). Does recreational computer use affect high school achievement? *Educational Technology Research and Development, 1*(61), 51-69.
<https://doi.org/10.1007/s11423-012-9274-1>
- Breuer, J., & Bente, G. (2010). Why so serious? On the relation of serious games and learning. *Journal for Computer Game Culture, 4*(1), 7-24. <https://hal.archives-ouvertes.fr/hal-00692052>
- Buelow, M. T., Okdie, B. M., & Cooper, A. B. (2015). The influence of video games on executive functions in college students. *Computers in Human Behavior, 45*, 228-234.
<https://doi.org/10.1016/j.chb.2014.12.029>

- Camacho Vásquez, G., & Ovalle, J. C. (2019). The influence of video games on vocabulary acquisition in a group of students from the BA in English teaching. *GIST Education and Learning Research Journal*, 19, 172-192.
- Charsky, D., & Mims, C. (2008). Integrating commercial off-the-shelf video games into school curriculums. *TechTrends*, 52(5), 38-44. <http://dx.doi.org/10.1007/s11528-008-0195-0>
- Charsky, D., & Ressler, W. (2011). “Games are made for fun”: Lessons on the effects of concept maps in the classroom use of computer games. *Computers & Education*, 56(3), 604-615. <https://doi.org/10.1016/j.compedu.2010.10.001>
- Checa-Romero, M., & Pascual Gómez, I. (2018). Minecraft and machinima in action: development of creativity in the classroom. *Technology, Pedagogy and Education*, 27(5), 625-637. <https://doi.org/10.1080/1475939X.2018.1537933>
- Chen, H.-J. H., & Yang, T.-Y. C. (2013). The impact of adventure video games on foreign language learning and the perceptions of learners. *Interactive Learning Environments*, 21(2), 129-141. <https://doi.org/10.1080/10494820.2012.705851>
- Cheung, A. C. K., & Slavin, R. E. (2012). How features of educational technology applications affect student reading outcomes: A meta-analysis. *Educational Research Review*, 7(3), 198-215. <https://doi.org/10.1016/j.edurev.2012.05.002>
- Choi, E., Shin, S.-H., Ryu, J.-K., Jung, K.-I., Kim, S.-Y., & Park, M.-H. (2020). Commercial video games and cognitive functions: Video game genres and modulating factors of cognitive enhancement. *Behavioral and Brain Functions*, 16(2). <https://doi.org/10.1186/s12993-020-0165-z>
- Coleman, T. E., & Money, A. G. (2020). Student-centred digital game-based learning: A conceptual framework and survey of the state of the art. *Higher Education*, 79(3), 415-457. <https://doi.org/10.1007/s10734-019-00417-0>

- Coller, B. D., & Scott, M. J. (2009). Effectiveness of using a video game to teach a course in mechanical engineering. *Computers & Education*, 53(3), 900-912.
<https://doi.org/10.1016/j.compedu.2009.05.012>
- Craft, J. (2016). Rebuilding an empire with Minecraft: bringing the classics into the digital space. *Classical Journal*, 111(3), 347-364. <http://dx.doi.org/10.5184/classicalj.111.3.0347>
- de Aldama, C., & Pozo, J.-I. (2019). Do you want to learn physics? Please play *Angry Birds* (but with epistemic goals). *Journal of Educational Computing Research*, 58(1), 3-28.
<https://doi.org/10.1177%2F0735633118823160>
- deHaan, J. W. (2005). Acquisition of Japanese as a foreign language through a baseball video game. *Foreign Language Annals*, 38(2), 278-282. <http://dx.doi.org/10.1111/j.1944-9720.2005.tb02492.x>
- deHaan, J., Reed, W. M., & Kuwada, K. (2010). The effect of interactivity with a music video game on second language vocabulary recall. *Language Learning & Technology*, 14(2), 74-94.
<http://ilt.msu.edu/vol14num2/dehaanreedkuwada.pdf>
- Diamond, A. (2013). Executive functions. *Annual Review of Psychology*, 64, 135-168.
<https://doi.org/10.1146/annurev-psych-113011-143750>
- Doerschuk, P., Juarez, V., Liu, J., Vincent, D., Doss, K., & Mann, J. (2013). Introducing programming concepts through video game creation. *2013 IEEE Frontiers in Education Conference*, 523-529. <https://doi.org/10.1109/FIE.2013.6684879>
- Ebrahimzadeh, M. (2017). Readers, players, and watchers: EFL students' vocabulary acquisition through digital video games. *English Language Teaching*, 10(2), 1-18.
<http://dx.doi.org/10.7575/aiac.ijalel.v.6n.4p.52>
- Ebrahimzadeh, M., & Alavi, S. (2016). Motivating EFL students: E-learning enjoyment as a predictor of vocabulary learning through digital video games. *Cogent Education*, 3(1), 1255400. <https://doi.org/10.1080/2331186X.2016.1255400>

- Elliott, R. (2003). Executive functions and their disorders: Imaging in clinical neuroscience. *British Medical Bulletin*, 65, 49-59. <https://doi.org/10.1093/bmb/65.1.49>
- Finco, M. D., Reategui, E., Zaro, M. A., Sheehan, D. D., & Katz, L. (2015). Exergaming as an alternative for students unmotivated to participate in regular physical education classes. *International Journal of Game-Based Learning*, 5(3), 1-10. <https://doi.org/10.4018/IJGBL.2015070101>
- Foster, A. N. (2011). The process of learning in a simulation strategy game: Disciplinary knowledge construction. *Journal of Educational Computing Research*, 45(1), 1-27. <https://doi.org/10.2190%2FEC.45.1.a>
- Franceschini, S., Gori, S., Ruffino, M., Viola, S., Molteni, M., & Facoetti, A. (2013). Action video games make dyslexic children read better. *Current Biology*, 23(6), 462-466. <https://doi.org/10.1016/j.cub.2013.01.044>
- Franceschini, S., Trevisan, P., Ronconi, L., Bertoni, S., Colmar, S., Double, K., Facoetti, A., & Gori, S. (2017). Action video games improve reading abilities and visual-to-auditory attentional shifting in English-speaking children with dyslexia. *Scientific Reports*, 7, 5863. <https://doi.org/10.1038/s41598-017-05826-8>
- Gibbs, B., Quennerstedt, M., & Larsson, H. (2017). Teaching dance in physical education using exergames. *European Physical Education Review*, 23(2), 237-256. <https://doi.org/10.1177%2F1356336X16645611>
- Gilbert, L. (2019). “Assassin’s Creed reminds us that history is human experience”: Students’ senses of empathy while playing a narrative video game. *Theory and Research in Social Education*, 47(1), 108-137. <http://dx.doi.org/10.1080/00933104.2018.1560713>
- Herodotou, C. (2018). Mobile games and science learning: A comparative study of 4 and 5 years old playing the game Angry Birds: Mobile games and science learning. *British Journal of Educational Technology*, 49(1), 6-16. <https://doi.org/10.1111/bjet.12546>

- Herrero, D., del Castillo, H., Monjelat, N., García-Varela, A. B., Checa, M., & Gómez, P. (2014). Evolution and natural selection: Learning by playing and reflecting. *Journal of New Approaches in Educational Research*, 3(1), 26-33. <https://doi.org/10.7821/naer.3.1.26-33>
- Hobbs, L., Stevens, C., Hartley, J., & Hartley, C. (2019). Science Hunters: An inclusive approach to engaging with science through Minecraft. *JCOM Journal of Science Communication*, 18(2). <https://doi.org/10.22323/2.18020801>
- Janebi Enayat, M., & Haghghatpasand, M. (2017). Exploiting adventure video games for second language vocabulary recall: A mixed-methods study. *Innovation in Language Learning and Teaching*. <https://doi.org/10.1080/17501229.2017.1359276>
- Jenny, S. E., Chung, J. J., Rademaker, S. M., & Schary, D. P. (2017). Learning a sport through video gaming: A mixed-methods experimental study. *Loading...*, 10(17), 1-20. <https://journals.sfu.ca/loading/index.php/loading/article/view/194>
- Jenny, S. E., & Schary, D. (2014). Exploring the effectiveness of learning american football through playing the video game “Madden NFL”. *International Journal of Technology in Teaching and Learning*, 10(1), 72-87.
- Jurcevic, J. S. (2008). Learning projectile motion with the computer game “Scorched 3D”. *Physics Teacher*, 46, 48-49. <https://doi.org/10.1119/1.2824001>
- Kim, M., & Shin, J. (2016). The pedagogical benefits of “SimCity” in urban geography education. *Journal of Geography*, 115(2), 39-50. <http://dx.doi.org/10.1080/00221341.2015.1061585>
- Kiryakova, G., Angelova, N., & Yordanova, L. (2014). Gamification in education. *Proceedings of 9th International Balkan Education and Science Conference*. <https://doi.org/10.4018/978-1-5225-5198-0>
- Klopper, E., Osterweil, S., & Salen, K. (2009). *Moving learning games forward*. Cambridge, MA: The Education Arcade.

- Krom, C. L. (2012). Using FarmVille in an introductory managerial accounting course to engage students, enhance comprehension, and develop social networking skills. *Journal of Management Education*, 36(6), 848-865. <https://doi.org/10.1177%2F1052562912459029>
- Lacasa, P., Martinez, R., & Mendez, L. (2008). Developing new literacies using commercial videogames as educational tools. *Linguistics and Education: An International Research Journal*, 19(2), 85-106. <https://doi.org/10.1016/j.linged.2008.02.001>
- Lamb, J. H. (2013). Angry Birds mathematics: Parabolas and vectors. *Mathematics Teacher*, 107(5), 334-340. <https://doi.org/10.5951/mathteacher.107.5.0334>
- Lee, J. K., & Probert, J. (2010). Civilization III and whole-class play in high school social studies. *Journal of Social Studies Research*, 34(1), 1-28.
- Marlatt, R. (2018). Literary analysis using Minecraft: An asian american youth crafts her literacy identity. *Journal of Adolescent & Adult Literacy*, 62(1), 55-66. <https://doi.org/10.1002/jaal.747>
- Masson, M. E. J., Bub, D. N., & Lalonde, C. E. (2011). Video-game training and naïve reasoning about object motion. *Applied Cognitive Psychology*, 25, 166-173. <https://doi.org/10.1002/acp.1658>
- McCord, A., Cocks, B., Barreiros, A. R., & Bizo, L. A. (2020). Short video game play improves executive function in the oldest old living in residential care. *Computers in Human Behavior*, 108, 106337. <https://doi.org/10.1016/j.chb.2020.106337>
- Medeiros, B. G. de, Pimentel, C. E., Sarmet, M. M., Mariano, T. E., Medeiros, B. G. de, Pimentel, C. E., Sarmet, M. M., & Mariano, T. E. (2020). "Brutal Kill!" Violent video games as a predictor of aggression. *Psico-USF*, 25(2), 261-271. <https://doi.org/10.1590/1413-82712020250205>

- Miller, D. J., & Robertson, D. P. (2011). Educational benefits of using game consoles in a primary classroom: A randomised controlled trial. *British Journal of Educational Technology*, 42(5), 850-864. <https://doi.org/10.1111/j.1467-8535.2010.01114.x>
- Miller, M., & Hegelheimer, V. (2006). The SIMs meet ESL Incorporating authentic computer simulation games into the language classroom. *Interactive Technology and Smart Education*, 4, 311-328. <https://doi.org/10.1108/17415650680000070>
- Monjelat, N., Mendez-Zaballos, L., & Lacasa, P. (2012). Problem solving processes and video games: The Sim City Creator case. *Electronic Journal of Research in Educational Psychology*, 10(3), 1493-1522.
- Newgarden, K., & Zheng, D. (2016). Recurrent languaging activities in World of Warcraft: skilled linguistic action meets the Common European Framework of Reference. *ReCALL*, 28(3), 274-304. <https://doi.org/10.1017/S0958344016000112>
- Nordine, J. C. (2011). Motivating calculus-based kinematics instruction with Super Mario Bros. *Physics Teacher*, 49(6), 380-382. <https://doi.org/10.1119/1.3628271>
- Novak, E., & Tassell, J. (2015). Using video game play to improve education-majors' mathematical performance: An experimental study. *Computers in Human Behavior*, 53, 124-130. <https://doi.org/10.1016/j.chb.2015.07.001>
- Nyberg, G., & Meckbach, J. (2017). Exergames 'as a teacher' of movement education: exploring knowing in moving when playing dance games in physical education. *Physical Education and Sport Pedagogy*, 22(1), 1-14. <https://doi.org/10.1080/17408989.2015.1112778>
- O'Rourke, J., Main, S., & Hill, S. M. (2017). Commercially available digital game technology in the classroom: Improving automaticity in mental-maths in primary-aged students. *Australian Journal of Teacher Education*, 42(10), 50-70. <https://doi.org/10.14221/ajte.2017v42n10.4>
- Oei, A. C., & Patterson, M. D. (2013). Enhancing cognition with video games: A multiple game training study. *PLoS One*, 8(3), e58546. <https://doi.org/10.1371/journal.pone.0058546>

- Overby, A., & Jones, B. L. (2015). Virtual LEGOs: Incorporating Minecraft into the art education curriculum. *Art Education*, 68(1), 21-27. <https://doi.org/10.1080/00043125.2015.11519302>
- Pagnotti, J., & Russell, W. B. (2012). Using Civilization IV to engage students in world history content. *Social Studies*, 103, 39-48. <https://doi.org/10.1080/00377996.2011.558940>
- Peng, P., & Kievit, R. A. (2020). The development of academic achievement and cognitive abilities: A bidirectional perspective. *Child Development Perspectives*, 14(1), 15-20. <https://doi.org/10.1111/cdep.12352>
- Pitarch, R. C. (2018). An approach to digital game-based learning: Video-games principles and applications in foreign language learning. *Journal of Language Teaching and Research*, 9(6), 1147-1159. <http://dx.doi.org/10.17507/jltr.0906.04>
- Prensky, M. (2003). Digital game-based learning. *Computers in Entertainment*, 1(1). <https://doi.org/10.1145/950566.950596>
- Ranalli, J. (2008). Learning english with The Sims: Exploiting authentic computer simulation games for L2 learning. *Computer Assisted Language Learning*, 21(5), 441-455. <https://doi.org/10.1080/09588220802447859>
- Riopel, M., Nenciovici, L., Potvin, P., Chastenay, P., Charland, P., Sarrasin, J. B., & Masson, S. (2020). Impact of serious games on science learning achievement compared with more conventional instruction: An overview and a meta-analysis. *Studies in Science Education*, 55(2), 169-214. <https://doi.org/10.1080/03057267.2019.1722420>
- Ruiz-Marquez, E., Prieto, A., Mayas, J., Toril, P., Reales, J. M., & Ballesteros, S. (2019). Effects of nonaction videogames on attention and memory in young adults. *Games for Health Journal*, 8(6). <https://doi.org/10.1089/g4h.2019.0004>
- Shah, M., & Foster, A. (2014). Undertaking an ecological approach to advance game-based learning: A case study. *Journal of Educational Technology & Society*, 17(1), 29-41. <https://www.jstor.org/stable/10.2307/jeductechsoci.17.1.29>

- Shute, V. J., Ventura, M., & Ke, F. (2015). The power of play: The effects of Portal 2 and Lumosity on cognitive and noncognitive skills. *Computers & Education, 80*, 58-67.
<https://doi.org/10.1016/j.compedu.2014.08.013>
- Siddaway, A. P., Wood, A. M., & Hedges, L. V. (2019). How to do a systematic review: A best practice guide for conducting and reporting narrative reviews, meta-analyses, and meta-syntheses. *Annual Review of Psychology, 70*, 747-770. <https://doi.org/10.1146/annurev-psych-010418-102803>
- Sierra, J. (2019). The importance of simulation in teaching and learning economics: The students' perspective. *Innovations in Education and Teaching International, 57*(5), 521-531.
<https://doi.org/10.1080/14703297.2019.1647268>
- Sitzmann, T. (2011). A meta-analytic examination of the instructional effectiveness of computer-based simulation games. *Personnel Psychology, 64*(2), 489-528.
<https://doi.org/10.1111/j.1744-6570.2011.01190.x>
- Squire, K., & Barab, S. (2004). Replaying history: Engaging urban underserved students in learning world history through computer simulation games. *ICLS '04: Proceedings of the 6th international conference on Learning sciences*, 505-512.
<https://dl.acm.org/doi/abs/10.5555/1149126.1149188>
- Stansbury, J. A., & Munro, G. D. (2013). Gaming in the classroom: An innovative way to teach factorial designs. *Teaching of Psychology, 40*(2), 148-152.
<http://dx.doi.org/10.1177/0098628312475037>
- Stansbury, J. A., Wheeler, E. A., & Buckingham, J. T. (2014). Can Wii engage college-level learners? Use of commercial off-the-shelf gaming in an introductory statistics course. *Computers in the Schools, 31*(1-2), 103-115.
<http://dx.doi.org/10.1080/07380569.2014.879791>

- Studer-Luethi, B., Bauer, C., & Perrig, W. J. (2016). Working memory training in children: Effectiveness depends on temperament. *Memory & Cognition*, *44*, 171-186.
<https://doi.org/10.3758/s13421-015-0548-9>
- Sun, C.-T., Ye, S.-H., & Wang, Y.-J. (2015). Effects of commercial video games on cognitive elaboration of physical concepts. *Computers & Education*, *88*, 169-181.
<https://doi.org/10.1016/j.compedu.2015.05.002>
- Sundqvist, P. (2019). Commercial-off-the-shelf games in the digital wild and L2 learner vocabulary. *Language Learning and Technology*, *23*(1), 87-113. <https://doi.org/10125/44674>
- Thompson, C. G., & von Gillern, S. (2020). Video-game based instruction for vocabulary acquisition with English language learners: A Bayesian meta-analysis. *Educational Research Review*, *30*, 100332. <https://doi.org/10.1016/j.edurev.2020.100332>
- Vahdat, S., & Rasti Behbahani, A. (2013). The effect of video games on iranian efl learners' vocabulary learning. *Reading Matrix: An International Online Journal*, *13*(1), 61-71.
<https://www.researchgate.net/publication/301340668>
- Wilkinson, B., Williams, N., & Armstrong, P. (2013). Improving student understanding, application and synthesis of computer programming concepts with Minecraft. *The European Conference on Technology in the Classroom 2013*. http://papers.iafor.org/wp-content/uploads/papers/ectc2013/ECTC2013_0477.pdf
- Wouters, P., van Nimwegen, C., van Oostendorp, H., & van der Spek, E. D. (2013). A meta-analysis of the cognitive and motivational effects of serious games. *Journal of Educational Psychology*, *105*(2), 249-265. <http://dx.doi.org/10.1037/a0031311>
- Wu, M.-H. (2019). The applications and effects of learning English through augmented reality: A case study of *Pokémon Go*. *Computer Assisted Language Learning*, 1-35.
<https://doi.org/10.1080/09588221.2019.1642211>

Yang, X., Wang, Z., Qiu, X., & Zhu, L. (2020). The Relation between electronic game play and executive function among preschoolers. *Journal of Child and Family Studies*, 29, 2868-2878.

<https://doi.org/10.1007/s10826-020-01754-w>

Zhonggen, Y. (2019). A meta-analysis of use of serious games in education over a decade.

International Journal of Computer Games Technology, 2019, 4797032.

<http://dx.doi.org/10.1155/2019/4797032>

