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Student Engagement in Game-Based Learning: A Literature Review

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Student Engagement in Game-Based Learning: A Literature Review

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Dedication

I would like to dedicate this report to my parents and lovely friends. Thank you for always supporting and encouraging me to keep moving forward.

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I would like to acknowledge Dr. Min Liu and Dr. Paul Resta for their assistance and feedback on this report. I appreciate their kindness, encouragement, and support during my stay in the University of Texas at Austin. Dr. Liu, thank you for your guidance on my coursework and supervision of my report. It's been a wonderful time to join and contribute to Alien Rescue and I appreciate the opportunity to work with you. Dr. Resta, thank you for your professional knowledge and useful advice in the projects and report I worked on. I want to express gratitude for your care and help.

I have been honored to work with the faculty in the excellent Learning Technologies program.

Abstract

Student Engagement in Game-Based Learning: A Literature Review

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Today's teens are digital natives: 87% of them have a desktop or laptop (Lenhart et al., 2015). Modern education is shifting from using traditional teacher-centered methods toward employing student-centered strategies. Game-based learning is not a new concept and has been adopted in both private and public schools. Although previous studies found that game-based learning is a sound strategy to engage learners, further research is needed to understand how engagement can influence learning and identify specific factors of game-based learning that affect learners. This report is a literature review of relevant journal articles on student engagement in game-based learning in K-12 and higher education. A total of twenty peer-reviewed journal articles from 2008 to 2018 were included in this report. The findings have showed that various factors have different effects (positive, negative, or no effects) on student engagement and that there is a close relationship between engagement and learning. The report also discusses measurement tools and research design issues. Finally, implications for future research are proposed.

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Chapter 1: Introduction

Student engagement is defined as a collection of goal-oriented behaviors and reflections to indicate a deep involvement in learning activities (Ke, Xie, K., & Xie, Y., 2016). The concept of student engagement has attracted growing interest among teachers and researchers as a way to reduce low academic achievement, student boredom, and distraction (National Research Council & Institute of Medicine, 1989). Deater-Deckard, Chang, and Evans (2013) noted that engaged learners will initiate, persist, and concentrate on mastering and applying knowledge, skills, and strategies for information processing or problem-solving.

Student engagement has a multifaceted nature and is defined in three subdomains. Behavioral engagement encompasses student participation; it includes involvement in school activities and is significant to achieve learning outcomes. Emotional engagement covers both positive and negative reactions to instructors, classmates, and schools; it is thought to build connections with other people and reflect students' willingness to complete tasks. Finally, cognitive engagement incorporates student investment, and it influences students' thoughtful efforts to understand complex knowledge and master difficult skills.

Students living in the information age are digital natives. According to Lenhart et al. (2015), 73% of teens had access to a smartphone, more than half had access to a tablet, and 87% had a desktop or laptop. Accordingly, the instructional methods used to teach these students should be different from those used in previous generations. Traditional education is defined as teacher-centered delivery of instruction to students who are the recipients of the instructional information. Innovative student-centered instructional methods have sprung up in recent years. Game-based learning is not a new concept and has been used in both private and public sectors. The U.S. military incorporates games to train officers and soldiers. Corporations also use games to educate new employees and train managers. Regarding digital game-based learning, the educational field has lagged behind other industries in innovation.

A common motivation to use game-based learning in education is the belief that games provide a fertile environment for deeper learning engagement within an authentic problem-solving setting (Gee, 2003). A good learning game involves students in an iterative problem-based learning process, where students examine and define the problem, explore what they have already learned, determine what they need to learn, evaluate possible solutions, and report findings. The unique nature of game-based learning is that the process is intensive but flow-like, where students are engaged and absorbed in working out solutions to problems (Csikszentmihalyi, 1997). Such a motivated state of engagement is crucial to an optimal learning experience and has been examined by scholars who are interested in using games to promote learning.

The empirical findings of student engagement in game-based learning are still inconsistent. Crisp et al. (2014) and Wouters et al. (2013) described game-based learning as a method to invoke engagement in students. Digital game-based learning elicited engagement by embedding learning within a gaming context, and research has demonstrated a positive relationship between engagement and student learning outcomes (Admiraal et al., 2011; Prensky, 2001). Gee (2007) also found that game-based methods engage students in deeper learning compared to traditional methods. However, Whitton (2007) found a direct relationship between game-play and learning engagement in games, and Chang et al. (2016) did not find a significant effect of math achievement on math engagement. Thus, there is need for a systematic review of empirical studies that focus on student engagement and game-based learning.

Although a growing number of literature reviews have been conducted to synthesize empirical studies of motivation, engagement, and learning in games (Jabbar & Felicia, 2015; Ke et al., 2016), the literature still lacks a well-established conceptualization of which factors affect engagement and how engagement influences learning outcomes in game-based learning. Drawing on student engagement in game-based learning, the goal of this report was to conduct a literature review of peer-reviewed articles from the past decade and to present findings to inform researchers who are interested in student engagement in learning games.

Purpose and overview of the report

This report is a literature review of relevant peer-reviewed articles on student engagement in game-based learning in K-12 and higher education from 2008 to 2018. The research synthesized in this literature review offers significant implications for educational game design. Given this purpose, the research questions guiding this literature review are:

(a) What factors influence student engagement in game-based learning?

(b) How does student engagement in game-based learning affect learning outcomes?

This report is organized into four chapters. The first chapter introduces the report's background, research motivation, and relevant gaps in research; it contextualizes the concepts of student engagement and game-based learning and provides an overview of this report. The second chapter describes the methodologies used in choosing studies, selection criteria, and the articles selected for inclusion. The third chapter presents the findings from empirical studies and discusses student engagement in game-based learning. The fourth chapter states the review's results and offers implications for future research and game design.

This literature review is constrained by several factors. First, some of the studies reviewed in this report only discussed factors affecting engagement or relationships between engagement and learning outcomes. Thus, it is beyond the scope of this research to identify connections between factors, engagement, and learning outcomes. In addition, most studies cover diverse portions of three subdomains of engagement and draw different conclusions, thereby making it much too complex to arrive at simple conclusions about individual factors that contribute to engagement. Finally, this research focuses on learning games; therefore, engagement in entertainment games, which is a broader area, is not examined.

Defining student engagement

Although the definitions and measurements of "student engagement" vary considerably, the term is generally used to describe the degree of attention, curiosity, passion, and interest that students show throughout their involvement in learning environments. In contrast, students' feelings of boredom, dispassion, and disaffection are defined as disengagement. Student engagement has been conceptualized as the simultaneous occurrence of high concentration, enjoyment, and interest (Shernoff, Csikszentmihalyi, Schneider, & Shernoff, 2003). It is a multifaceted and complex construct measured by three dynamically interrelated dimensions: behavioral engagement, emotional engagement, and cognitive engagement.

Behavioral engagement refers to students' involvement, concentration, and persistence in academic tasks including behaviors such as following rules, making an effort, paying attention, and asking questions (Finn, Pannozzo, & Voelkl, 1995; Skinner & Belmont, 1993). The majority of studies have investigated behavioral engagement in relation to students' participation (Jimerson, Campos, & Greif, 2003) and their adherence to rules (Lan et al., 2009). In general, these studies have not made distinctions among various kinds of on-task behavior, while a few studies separate cooperative participation from autonomy and self-directed academic behaviors (Birch & Ladd, 1997; Buhs & Ladd, 2001).

Emotional engagement, also called affective engagement, reflects students' feelings and has positive and negative poles. It has been defined as students' affective reactions, which covers interest, boredom, happiness, sadness, and anxiety (Connell & Wellborn, 1991; Skinner & Belmont, 1993). Eccles at al. (1983) described four components as valuable to emotional engagement: interest, attainment, the importance of tasks, and cost. Csikzentmihalyi (1988) developed flow theory to make a distinction between positive emotions and high involvement, or "flow." He defined "flow" as a subjective state of complete involvement, whereby individuals are so absorbed in activities that they become unaware of time and space.

Cognitive engagement is a psychological investment in learning, understanding, and mastering knowledge, skills or crafts (Newman, 1992). Connell and Wellborn (1991) defined cognitive engagement as flexibility in problem-solving, positive attitudes toward failure, preference for hard work, and a desire to go beyond the requirements. Cognitive engagement encompasses motivation, effort, and strategy as they are applied to learning activities (Fredricks, Blumenfeld, & Paris, 2004). Students managed and controlled their efforts to sustain cognitive engagement (Corno, 1993; Pintrich & De Groot, 1990) and used metacognitive strategies to plan, monitor, and evaluated their work when finishing tasks (Pintrich & De Groot, 1990; Zimmerman, 1990).

The current definitions of behavioral, emotional, and cognitive engagement have been noted; however, the engagement literature lacks sufficient differentiation between various types of engagement and sometimes contains duplicate concepts. For instance, effort was included as part of behavioral and cognitive engagement (Fredricks et al., 2004), autonomy was covered in behavioral engagement (Eseryel et al., 2014), and control was encompassed in cognitive engagement (Ke & Abras, 2013). Despite these problems, the author argues that student engagement has considerable potential as a multidimensional construct uniting behavioral, emotional, and cognitive engagement in a meaningful way. In this respect, student engagement could be considered as a meta-construct (Fredricks et al., 2004).

THE CONCEPT OF DIGITAL GAME-BASED LEARNING

Game-based learning is a type of gameplay that has learning outcomes, which makes it distinct from entertainment-oriented games. Game-based learning, the focus of this study, is designed and developed for the primary purpose of educating or training students. It encourages positive affect, engagement, and motivation in learning by using game-like features and environments (Gee, 2003; Shaffer, 2006). Digital games can attract and hold children's attention for hours, so it is not surprising that teachers and scholars are interested in their potential as an educational tool. Studies have shown that children enjoy game-based learning tasks more than traditional learning tasks (Barrera, Rule & Diemart, 2001; Rosas et al., 2003; Wrzesien & Raya, 2010).

It has been well documented that game-based learning has the potential to encourage students to explore beyond the boundaries of given materials and allow them to become self-directed learners. Oblinger and Rickard (2004) described how game-based learning gives learners opportunities to learn by doing. O'Brien and Tom (2008) pointed out that student involvement and participation in learning activities are constructed through positive interaction with the learning environment. Pinelle, Wong, and Stach (2008) emphasized the relationship between game interface and development of players' learning skills. When evaluating mobile game-based learning, Schwabe and Göth (2005) found that immersion in a mixed reality leads to a highly motivating learning experience.

Engagement is an important concept in game-based learning research. In game-based learning, students engage in activities like problem identification, hypothesis-making, and critical thinking (Maertens et al., 2014). Wouters et al. (2013) did a meta-analysis and found that serious games were effective in increasing student engagement and positive effect. Important indicators of engagement such as effort and persistence (Ryan & Deci, 2000) were interpreted based on the amount of time a player spends on a task and the number of tasks that a player accomplishes. Alessi and Trollip (2001) concluded that educational game goals should be designed to attract student attention and promote student engagement.

Scholars have begun to study the relationship between engagement and game-based learning. Prensky (2001) stated that digital game-based learning accentuated engagement by introducing learning into a gaming context. There was a positive relationship between the degree of engagement and student learning outcomes (Admiraal et al., 2011). Compared with traditional educational settings, location-based technology provided opportunities to embed learning in authentic environments and enhance learning and engagement (Klopfer & Squire, 2008). Gee (2007) described how video games invite participation and collaboration, thereby engaging students in deeper learning.

Early studies showed that students' situational interest triggered by educational games was short-lived (Goodwin et al., 1986; Kerawalla & Crook, 2005). However, additional research suggested that individual interest, a relatively enduring predisposition to seek repeated reengagement, can be maintained for a longer period (Hidi & Renninger, 2006). Even though both cognitive and motivational effects of game-based learning have been studied, there was a need to thoroughly evaluate the cognitive benefits of game-based learning (De Freitas, 2006; Gros 2007;

Habgood, 2007). Harp and Mayer (1998), Mayer and Johnson (2010), and Rowe et al. (2009) criticized game-based learning for having features that distracted students' attention away from learning tasks. Thus, it is important to fully understand how specific game features correspond to engagement and learning outcomes.

Chapter 2: Method

The literature selection followed the flow outlined in the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) statement (Moher, Liberati, Tetzlaff, Altman, & Prisma Group, 2009), including four phases: identification, screening, eligibility, and articles included. In the identification phase, researchers identify the number of records through database searching and additional records from other sources, then remove duplicates. Then, in the screening phase, they screen records and exclude those that do not meet selection criteria. In the eligibility phase, they examine additional records from references and add them. In the last phase, they count the total number of records being included.

IDENTIFICATION

In the identification phase, electronic databases were chosen to search for relevant literature. These databases included ERIC, JSTOR, LearnTechLib, ScienceDirect, Wiley Online Library, and The University of Texas at Austin Online Library. The search was limited to papers published in peer-reviewed journals between 2008 and 2018. The following journals were taken into consideration: *Advances in Engineering Education, Australasian Journal of Educational Technology, British Journal of Educational Technology, Canadian Journal of Action Research, Computer & Education, Computers in Human Behavior, Educational Information Technology, Educational Technology & Society, IEEE Transactions on Affective Computing, International Journal of Artificial Intelligence in Education, International Journal of Science Education, Journal of Computer Assisted Learning, Language Learning & Technology*, and *Simulation & Gaming*. The author used “game-based learning,” “game engagement,” “learning outcomes,” “learning achievement” and their combinations as keywords to search for related articles. In total, 74 potentially relevant papers were found. After the removal of duplications, 60 articles remained.

SCREENING

The following criteria were specified to select appropriate journal articles for literature review:

(1) the article focused on student engagement in game-based learning;

(2) samples were K-12 and college students.

Studies that did not meet both of the criteria were excluded. After screening the 60 articles selected in the previous phase, 43 articles did not meet the criteria.

ELIGIBILITY

After screening, 17 empirical research articles were considered for inclusion. The author identified 3 additional papers from the references of articles searched to be added to the pool.

ARTICLES INCLUDED

In the last phase, a total of 20 articles were considered for this Master's report.

There are many variations in those articles (See Table 1). Student engagement in game-based learning was examined in populations ranging from elementary school students to college students. Seven studies were conducted in elementary schools, six studies were conducted in middle schools, four studies were conducted in high schools, and the remaining three studies were conducted in colleges. The research sites were located across North America, Europe, Australia, and Asia. Twelve of the studies were conducted in the United States, while others were not. All of the studies were conducted in developed countries or regions.

Table 1

Empirical studies on engagement and game-based learning reviewed in the report

Author(s), Year	Research Site	Sample	Methods	Game Name	Key Findings	Journal
Allen, Crossley, Snow, & McNamara (2014)	Metropolitan Phoenix area, USA	42 high school students	Quantitative	*Writing Pal*	Second language students' engagement towards learning tasks was strongly related to their enjoyment of the practice environment.	Language Learning & Technology
Annetta, Mangrum, Holmes, Collazo, & Cheng (2009)	North Carolina, USA	74 elementary school fifth-grade students	Mixed	*MEGA*	Results suggested that there was high student engagement during the MEGA intervention.	International Journal of Science Education
Annetta, Minogue, Holmes, & Cheng (2009)	Southeast, USA	129 high school students	Quantitative	*MEGA*	Statistical results indicated no differences in student learning, but there were significant differences in the participants' level of engagement while interfacing with the video game.	Computers & Education

Table 1 (Continued)

Author(s), Year	Research Site	Sample	Methods	Game Name	Key Findings	Journal
Chang et al. (2016)	Virginia, USA	107 fifth-grade students	Quantitative	*APP*	Students’ overall engagement levels were significantly different, but no significant difference was found when comparing male and female. No significant effect of math achievement was found on math engagement.	Educational Information Technology
Coller, Shernoff, & Strati (2011)	Northern Illinios University	155 undergraduate students	Quantitative	*EduTorcs*	Results suggested that students were significantly more engaged in Year 3 when they were working on their game-based homework and lab work, compared to students in Year 1, whose coursework was not game-based.	Advances in Engineering Education
Eseryel, Law, Ifenthaler, Ge, & Miller (2014)	Midwest, USA	88 high school ninth-grade students	Quantitative	*McLarin’s Adventures*	Results indicated that participants’ self-efficacy was a significant predictor of their engagement during gameplay. In contrast, interest and competence negatively predicted the participants’ engagement during gameplay. Students’ motivation and engagement had a critical impact on students’ development of complex problem-solving competencies in game-based learning.	Educational Technology & Society

Table 1 (Continued)

Author(s), Year	Research Site	Sample	Methods	Game Name	Key Findings	Journal
Filsecker & Hickey (2014)	Midwest, USA	116 elementary school fifth-grade students	Quantitative	*Quest Atlantis*	Rewards did not undermine students' motivation; however, they also did not foster disciplinary engagement.	Computers & Education
Hamari et al. (2016)	USA	134 high school students 40 undergraduate students	Quantitative	*Quantum Spectre* *Spumone*	Results indicated that the conditions of flow (challenge and skill) account for engagement. In turn, flow conditions (challenge and skill) and the experience of being in flow (engagement and immersion) accounted for perceived learning. Challenges had a positive direct effect on engagement.	Computers in Human Behavior
Hsieh, Lin, & Hou (2015)	Taiwan	34 fourth- to sixth-grade elementary students	Quantitative	*Happy Black-faced Spoonbill*	The game could consistently increase students' engagement in the game-based learning environment.	Educational Technology & Society
Huizenga, Admiraal, Akkerman, & Dam (2009)	Amsterdam, The Netherlands	458 secondary school students	Quantitative	*Frequency 1550*	Results showed those pupils who played the game to be engaged and to gain significantly more knowledge about medieval Amsterdam than those pupils who received regular project-based instruction.	Journal of Computer Assisted Learning

Table 1 (Continued)

Author(s), Year	Research Site	Sample	Methods	Game Name	Key Findings	Journal
Islas Sedano, Leendertz, Vinni, Sutinen, & Ellis (2013)	Finland	101 grade 7 students	Mixed	*LIEKSAMYST*	Fantasy was the central factor that triggered affective and cognitive engagement. The in-game exam results and the pupils' school grades did not correlate.	Simulation & Gaming
Ke & Abras (2013)	Southwest, USA	9 middle school students	Quantitative	*Lure of the Labyrinth*	Well-designed and properly used games could promote engagement and learning for students with special learning needs.	British Journal of Educational Technology
Lowrie, Jorgensen, & Logan (2013)	Australia	410 middle school students	Mixed	*The Legend of Zelda: Phantom Hourglass*	Results showed distinct differences in both the approach and the strategies that participants employed not only to engage with the game, but also to contextualize it within their own knowledge and experiences.	Australasian Journal of Educational Technology

Table 1 (Continued)

Author(s), Year	Research Site	Sample	Methods	Game Name	Key Findings	Journal
Pontual Falcão, Mendes de Andrade e Peres, Sales de Morais, & da Silva Oliveira (2018)	N/A	6 experts (5 undergraduate students and 1 graduate student); 19 novices aged 15-16 years	Qualitative	*DEMULTS*	Even in a supposedly fun and innovative context, the relationship between the object of the activity and the students' needs was crucial to promote engagement and learning.	Computers & Education
Riemer & Schrader (2016)	Germany	97 undergraduate students	Quantitative	*Cure Runners*	The more the participants engaged in self-monitoring behavior, the more accurate their mental models became.	Computers in Human Behavior
Ronimus, Kujala, Tolvanen, & Lyytinen (2014)	Finland	138 first-grade and second-grade students	Mixed	*GraphoGame*	Results suggested that although fantasy elements and novel task types may increase children's engagement in playing digital learning games, this effect might not be long-lasting, at least if there were shortcomings in the game design. The level of challenge had no significant effect on children's engagement.	Computer & Education

Table 1 (Continued)

Author(s), Year	Research Site	Sample	Methods	Game Name	Key Findings	Journal
Rowe, Shores, Mott, & Lester (2011)	USA	153 middle school students	Quantitative	*CRYSTAL ISLAND*	Results showed a strong positive relationship between learning outcomes, in-game problem-solving and increased engagement. The relationship between learning outcomes and engagement held even when controlling for students' background knowledge and game-playing experience. Males tended to report significantly greater presence in the virtual environment than females, and students with more game-playing experience reported significantly greater presence in the virtual environment than students with minimal game-playing experience.	International Journal of Artificial Intelligence in Education
Sabourin & Lester (2014)	North Carolina, USA	450 Middle School eighth-grade students	Quantitative	*CRYSTAL ISLAND*	Results showed that the individual metrics that were used to generate the problem-solving clusters did not correlate to learning or engagement outcomes.	IEEE Transactions on Affective Computing

Table 1 (Continued)

Author(s), Year	Research Site	Sample	Methods	Game Name	Key Findings	Journal
Schaaf (2012)	Maryland, USA	280 elementary school students	Mixed	Students are in self-contained classrooms and choose 14 games based on their own web search	Results showed a higher average level of student enjoyment while experiencing DGBL. Equal or higher class average scores were produced for focus and attentiveness during DGBL versus alternative strategies. The data suggested that DGBL can be as effective in the classroom as other research-proven instructional strategies.	Canadian Journal of Action Research
Vasalou, Khaled, Holmes, & Gooch (2017)	North London, UK	8 students in fifth grade	Qualitative	*Words Matter*	Findings suggested that game features were endowed with meaning during social interaction. These features consequently fostered different forms of social engagement which serve different ends, ranging from the desire to strengthen group identity to enabling social comparison or connectedness.	Computer & Education

Chapter 3: Findings and Discussion

Studies showed that digital game-based learning can promote and increase student engagement in learning (Annetta Minogue, Holmes, & Cheng, 2009; Hsieh, Lin, & Hou, 2015; Ke & Abras, 2013; Schaaf, 2012). When comparing students who receive traditional non-game-based education to students who receive game-based education, studies have found the latter group to be much more engaged with their homework and lab work (Coller, Shernoff, & Strati, 2011). To be more specific, students experienced an increase in behavioral engagement when immersed in game-based learning (Chang et al., 2016). Riemer and Schrader (2016) found a high correlation between behavioral engagement measures and game-based learning. This chapter will address the following two questions: a) what factors influence students' engagement in game-based learning? b) how does student engagement in game-based learning affect learning outcomes? In answering these questions, the first section lists all the factors that affect engagement and have been examined by empirical studies; the second section compiles results extracted from research studying the connections between engagement and game-based learning. Finally, the last section discusses measurement issues and research design problems of the studies reviewed by this report.

FACTORS BEING ANALYZED AND THE EXTENT OF THEIR EFFECTS ON STUDENT ENGAGEMENT

Studies have noted that engagement in games was related to a wide range of elements inherent in games as well as players' attributes (Boyle, Connolly, Hainey, & Boyle, 2012; Connolly et al., 2012). As described in the method section, scholars explored different factors to determine whether or not they influence student engagement in game-based learning. This section describes the findings that address the first research question:

Which factors affect student engagement in game-based learning? The factors examined by these empirical studies included relatedness, frequency, competence/skill, gender, enjoyment, interest, self-efficacy, autonomy, control, challenge, presence, fantasy, social interaction, task characteristics, rewards, and technical problems (see Table 2). Not all of these factors were found to have promising effects on engagement. These factors are described in detail below.

Table 2

List of factors affecting engagement reviewed in this report

Factors affecting engagement	Findings	Reference
Competence	Competence negatively predicted the participant's engagement during gameplay.	Eseryel et al. (2014)
Skill	There was a significant path coefficient between skill and engagement.	Hamari et al. (2016)
Relatedness	The students' experience relatedness did not influence their engagement.	Eseryel et al. (2014)
Frequency	There were significant differences significant differences between game-playing frequency group and presence.	Rowe et al. (2011)
Frequency	Playing digital games often outside of class corresponded to significantly lower levels of engagement.	Coller, Shernoff, & Strati (2011)
Enjoyment	Students' enjoyment level was not affected by the game features investigated in the present study.	Ronimus et al. (2014)
Enjoyment	Second language students' engagement towards learning tasks was strongly related to their enjoyment of the practice environment.	Allen et al. (2014)

Table 2 (Continued)

Factors affecting engagement	Findings	Reference
Interest	The higher the loss of interest and competence observed, the higher the engagement was.	Eseryel et al. (2014)
Self-efficacy	Students' self-efficacy had a significantly positive impact on their engagement in tasks.	Eseryel et al. (2014)
Autonomy	Students' perceived autonomy and experience relatedness did not influence their engagement.	Eseryel et al. (2014)
Challenge	Challenges had a significantly positive direct effect on engagement.	Hamari et al. (2016)
Challenge	The level of challenge did not affect children's engagement in playing.	Ronimus et al. (2014)
Challenge	Challenges that were open-ended and allowed for partial success helped to maintain engagement. Speeded challenges should be avoided to provide more time for cognitive processing.	Ke & Abras (2013)
Control	Allowing players to create their identity and enact their unique trajectory reinforced a sense of control for a general player group.	Ke & Abras (2013)
Presence	Only presence and situational interest were investigated as engagement-related variables.	Rowe et al. (2011)
Gender	Boys were more likely to play games with a strong dynamic component.	Lowrie, Jorgensen & Logan (2013)
Gender	Males tended to feel significantly more involved/in control when interacting with the game than females. There was no significant effect of gender on presence.	Rowe et al. (2011)

Table 2 (Continued)

Factors affecting engagement	Findings	Reference
Fantasy	Through the game's simulation of players' fantasy, students became affectively and cognitively engaged. Fantasy was the central factor that triggered affective and cognitive engagement.	Islas Sedano et al. (2013)
Social interaction	Engagement was driven by social motives including speech with peers.	Vasalou et al. (2017)
Task characteristics	Higher engagement was related to different tasks of operating the computer.	Huizenga et al. (2009)
Rewards	The external rewards did not significantly foster disciplinary engagement.	Filsecker & Hickey (2014)
Technical Problems	Technical problems negatively influenced the engagement.	Huizenga et al. (2009)
Rewards	Reward systems initially triggered children's interest, but the session durations returned to typical levels when the number of serial play sessions increased. The presence of the reward system had a significant effect on concentration.	Ronimus et al. (2014)

Frequency

Frequency is the number of times a game is played repeatedly per unit of time. Scholars have investigated the frequency of game-playing both outside of class and within class. Coller, Shernoff, and Strati (2011) found that playing digital games frequently outside of class significantly corresponded to lower levels of engagement in *EduTorcs*. In the interview after playing *EduTorcs*, it was stated that, compared to commercial games, educational games might fail to meet students’ expectations and thus decrease their interest in solving tasks while playing the game. However, Rowe, Shores, Mott, and Lester (2011) found significant differences between in-class game playing frequency and presence. In their game, *CRYSTAL LAND*, students in the low-frequency group felt less engaged than students in the high-frequency group. It was reported that students with low frequency completed fewer goals than the students in the opposite group. As the first study examined outside class playing game frequency, while the latter investigated in-class frequency, it is challenging to draw an overall conclusion about the effects of term frequency on engagement.

Competence/Skill

Students' perceptions of their own competence and skill were determinants of achievement and motivation (Nicholls, 1979; White, 1959). Thomas (1980) argued that the perception of competence and corresponding perceptions of one's chances of success were fundamental motivators for learning. Competence influenced students' understanding of problems and the quality of the solutions they develop (Pintrich, 2000). The results about competence, which were reviewed by this report, were various. In a study conducted by Hamari et al. (2016), a significant path coefficient was found, indicating that skill had a positive direct effect on engagement. To succeed in the game *Spumone*, students had to come up with strategies based on the principles they had learned in the course and express those strategies through an equation. Students' prerequisite skill affected their performance in the gameplay. However, in a study conducted by Eseryel, Law, Ifenthaler, Ge, and Miller (2014), competence was found to negatively predict the participants' engagement during gameplay. Students with high competence easily overcame the obstacles and lost interest when playing the game. The game failed to meet their expectations, which meant that there was a gap between the game and students' competence.

Relatedness

Relatedness is students' feeling of belonging in the classroom. It could be acceptance, inclusion, and support from the class. It could also be the quality of the relationship between students and teachers (Reeve, 2006). In game-based learning, relatedness refers to the relationship among players (Ryan, Rigby, & Przybylski, 2006), and it can be fostered by collaboration. Eseryel et al. (2014) found that students' experience of relatedness did not influence their engagement. Even though students were involved in working toward the same goals and solving problems together, the peer relationship did not influence their engagement.

Gender

Rowe et al. (2011) found that males were significantly more involved when interacting with *CRYSTAL ISLAND* than females. Males tended to give higher ratings on the game interface than females, which suggested that the 3D interface design of *CRYSTAL ISLAND* was more attractive to males. *The Legend of Zelda: Phantom Hourglass* used a combination of 2D and 3D virtual space, creating narrative environment similar to that of *CRYSTAL ISLAND*. Boys were more likely to play games with a strong dynamic component and were more likely to enjoy the maps in *The Legend of Zelda: Phantom Hourglass* (Lowrie, Jorgensen, & Logan, 2013). Interview results showed that boys were fond of interpreting the information from maps in this game.

Enjoyment

Enjoyment is the process of taking pleasure in playing games. Educational games have been proposed as a method to provide engaging instruction by leveraging students' intrinsic enjoyment (Gee, 2003, 2007). In a study of the game *Writing Pal*, Allen et al. (2014) found that second language students' engagement towards learning tasks was strongly related to their enjoyment of the practice environment. Students' perception of learning gains and writing improvement were positively related to game enjoyment. The enjoyment level was found to not be affected by the game features investigated in the study of *GraphoGame*, in which a female voice asked students how much they enjoyed playing the game (Ronimus et al., 2014). Students responded by selecting one face from a set of options ranging a big smile to a big frown. Results showed that students' initial levels of enjoyment were high and that initial enjoyment varied between individuals, but there was no significant change in enjoyment during the training period.

Fantasy

Fantasy transports the player to an imaginary world (Malone, 1980). A study of the educational game *LIEKSAMYST* found that fantasy enabled students to feel useful and helpful as they solved problems for the characters in the game. The main finding was that fantasy was the central factor that triggered affective and cognitive engagement while students played *LIEKSAMYST* (Islas Sedano et al., 2013). The game environment stimulated students' sense of fantasy, which in turn encouraged their in-game engagement.

Interest

Interest is the state of wanting to know or learn about the game. In *CRYSTAL ISLAND*, students' interest was measured by an adapted scale from Schraw (1997). Their willingness to talk about the game with others, the fondness of the game topic, and wanting to play again were the strong indicators of students' interest. Situational interest was investigated in a study as a variable related to engagement (Rowe et al., 2011). When playing *CRYSTAL ISLAND*, the more interested students were, the more engaged they were. However, Eseryel et al. (2014) found that interest was negatively related to engagement among students playing *McLarin's Adventures*. An in-depth analysis of the data and post-interviews showed that students were initially highly interested in playing *McLarin's Adventures*, but their interest decreased later because the game did not meet their expectations.

Self-efficacy

Self-efficacy refers to an individual's belief in his or her ability to achieve a desired goal (Bandura, 1997). Pajares (1996) found that self-efficacy was a strong predictor of learning outcomes. Research showed that students gain higher motivation via greater self-efficacy and self-worth (Convington, 1985). In the game setting, when students achieved their goals, their self-efficacy would be increased; their self-efficacy might diminish when they observed other players struggling with the tasks. Zimmerman and Campillo (2003) concluded that game players with high self-efficacy were more likely to move forward and persist in game-solving tasks. Eseryel et al. (2014) proved that there was a significantly positive influence of students' self-efficacy on their engagement using the game *McLarin's Adventures*. The more self-efficacy students had, the more engaged they were. Students with increased self-efficacy put more effort into solving problems and were more persistent in completing the task.

Autonomy

Ryan and Powelson (1991) defined autonomy as regulating one's own behavior and experience and governing the initiation and direction of action. Any constraints in games may limit students' choices and hence reduce their autonomy. A study showed that students' perceived autonomy did not influence their engagement (Eseryel et al., 2014). Even though students were free to control the game environment in *McLarin's Adventures*, this autonomy did not greatly affect their engagement in the game.

Control

Personal control allows the player to be in charge of a situation. Gee (2003) found that allowing students to create their own identities and enact unique trajectories reinforced students' sense of control. Another study confirmed this reinforcing effect in a group of students with special learning needs (Ke & Abras, 2013). Participants reported that they were comfortable and confident in playing *Ker-Splash* because they could change the route of a rolling ball and keep the route under control. In the game *Lure of Labyrinth*, players were excited about creating their own avatars and choosing their favorite pets. In the game *LIEKSAMYST*, results showed that students felt enjoyment and engagement at their own pace (Islas Sedano et al., 2013). Students were able to seek information at their own pace and thereby control the speed of the story.

Challenge

Students in a 1992 study stated that they valued cognitive complexity and liked to complete challenging school work (Newmann, Wehlage, & Lamborn, 1992). National studies have repeatedly found that lack of challenges is one of the reasons for student disengagement (Shernoff, 2013; Yazzie-Mintz, 2007). Ronimus et al. (2014) found that the level of challenges did not significantly affect the total playing time of *GraphoGame*. The challenges in the game were appropriate—or at least not hard—for students, and the levels of challenge did not produce a difference in student engagement. The findings suggested that game challenges should be open-ended and allow for partial success, and speeded challenges should be avoided as they may cause cognitive over-processing (Ke & Abras, 2012). In game-based learning, the challenges that students face should be surmountable and match students' developed skills.

Presence

Presence is the state of being absorbed in the game. Rowe et al. (2011) used the validated questionnaire created by Witmer and Singer (1998) to test students' feelings of presence. Involvement, control, the naturalism of experience, and quality of interface were subscales in the questionnaire. The naturalism subscale assessed students' perceptions of the virtual environment in *CRYSTAL LAND*; the interface subscale indicated how control and display devices were integrated into the interaction experience. The researchers investigated presence and concluded that this variable was related to engagement. Students' sense of presence in the game was closely linked to their engagement and problem-solving performance.

Social Interaction

In the course of gameplay, students will talk and share their experiences with their peers. Vasalou et al. (2017) pointed out that children seek to "synchronize" their game experience with others, to foster a sense of group identity, and to facilitate comparisons with peers. When synchronicity was achieved, students felt affirmed in their choices and reinforced at a group level. As a result, this study concluded that engagement was driven by social motives. However, it could also be argued that talking with peers would distract students away from focusing on the game. The conversation between students would alienate them from concentrating on problem-solving and finishing tasks. To conclude, social interaction serves multiple functions for players, including peer collaboration, group synchronicity, and distraction from tasks. All of these functions might blur together to influence student engagement in game-based learning.

Task Characteristics

"Task characteristics" refers to the features or qualities of a task. In *Frequency 1550*, high student engagement was found to be related to the variety of different tasks included in the game (Huizenga et al., 2009). The task of gaining citizenship in the city of Amsterdam by getting points and obeying certain in-game rules made this game attractive to the students and kept them actively engaged in the main storyline.

Rewards

Rewards are items given in recognition of students' effort or achievement. According to cognitive theory, rewards are inimical to students' intrinsic motivation and subsequent engagement because they undermine students' perceptions of competence and autonomy. Filsecker and Hickey (2014) proved that external rewards did not significantly foster disciplinary engagement. They found that the rewards in the game *Quest Atlantis* were not enough to help students set valuable learning goals that would keep them engaged. In the game *GraphoGame*, a reward system initially triggered children's interest, but the session durations were reduced back to typical level when the number of serial play sessions increased; overall, the rewarding system was found to have a significant effect on concentration (Ronimus et al., 2014).

Technical Problems

A technical problem is a problem involving the way a machine or system works. In the game, technical problems refer to the problems that devices, operating systems, or the game system itself may have. Huizenga et al. (2009) pointed out that technical problems negatively influenced student engagement. In their game, *Frequency 1550*, the technology did not always work as planned. The problems were that the GPS showed the wrong or no direction to students and that the game operated at a low speed when sending photographs and videos; as a result of these problems, students accomplished fewer tasks than expected. Technical issues prevented the students from moving forward to next assignment and made them less engaged in the game. Their results showed that technical problems were associated with disengagement in more than 50% of instances.

Summary

This section has synthesized the factors that affect student engagement in game-based learning of empirical studies from 2008 to the present. Overall, sixteen factors were examined by previous studies, but the studies produced conflicting results. To be specific, several factors, including frequency, competence/skill, interest, control, social interaction, and rewards, were found to positively or negatively to affect student engagement by different studies in different research settings. The reasons for these different findings may be: a) researchers used the same factor term but tested different variables or b) researchers did not define the degree of the factor. For example, Coller, Shernoff, and Strati (2011) studied the frequency of student game-playing outside class, while Rowe et al. (2011) used the same term but studied in-game playing frequency; Hamari et al. (2016) found a positive relationship between students' adequate competence and engagement, while Eseryel et al. (2014) found negative effects because the students' competence far exceeded the challenges of the game. Studies found that relatedness, enjoyment, and autonomy had no effect on student engagement; fantasy, self-efficacy, control, presence, and task characteristics were identified as contributors to student engagement; technical problems decreased student engagement. Even though there was no discrepancy in those conclusions, the reliability of each factor's effect needs to be improved. Due to the fact that some of the factors were researched only once in the empirical studies reviewed in this report, repeated studies are needed to test the validity of these findings under various circumstances. In addition, many factors like enjoyment and rewards initially motivated students, but their effects decreased with the passage of time. Consequently, it is necessary to investigate what factors lead to declining engagement, what factors could help students set valuable goals, and what factors could sustainably keep students engaged over time.

THE RELATIONSHIP BETWEEN ENGAGEMENT AND LEARNING

In the previous section, the report listed all factors that may affect student engagement in game-based learning. The following section describes studies that focus on the connection between engagement and learning outcomes. The primary goal of this section is to address the second research question: How does student engagement in educational games affect learning outcomes? A total of 13 studies out of 20 selected articles analyzed the connection between engagement and learning. None of them found a negative relationship.

Annetta, Minogue, Holmes, and Cheng (2009) stated that motivation and engagement alone did not ensure achievement, but cognitive engagement did mediate learning and achievement. Specifically, in their problem-based game *MEGA*, students who played the game did not demonstrate a greater understanding of the genetics concepts. The technology had the benefit of serving as a hook to invite learners' participation. The findings reinforced the critical need to isolate cognitive engagement from the other two types and to investigate the specifically cognitive impact of educational games. Cognitive processing was only one of the factors that may contribute to effective learning, so the authors recommended that future studies explore affective impacts and motivational factors as well.

Chang et al. (2016) did not find a significant effect of math achievement on math engagement; this result did not match those of previous studies showing there were significant effects (Barkatsasa, Kasimatisb, & Gialamas, 2009; Marks, 2000). Students who used the *APP* game to acquire math skills showed a great improvement in their engagement compared with the control group, but their math achievement was not correlated with the increased engagement. This study recommended experimental research to examine the effects of differential math abilities on overall engagement and three sub-domains.

Eseryel et al. (2014) identified a positive relationship between student engagement and their learning outcome. *McLarin's Adventures* is a massive online multiplayer game. This study showed that the more students were engaged in this game, the higher their final learning outcomes were. The authors pointed out that the critical issue for the educational game design was to sustain student motivation and engagement during game play. They suggested that new and increasingly challenging game scenarios could keep students focused.

Two factors contributing to engagement, challenge and skill, were shown to partially mediate perceived learning in the games *Spumone* and *Quantum Spectre*. Studies of these two games posited that engagement was a critical aspect of learning. Harami et al. (2016) provided evidence that skill did not affect learning directly but impacted learning via a significant mediation effect of engagement, while challenge had both direct and mediated effects on perceived learning. These findings implied that the question of how skill and challenge affect learning outcomes differently remains unclear and warrants further investigation.

Huizenga et al. (2009) showed that playing the game *Frequency 1550* produced a clear learning effect in terms of acquiring historical knowledge of medieval Amsterdam. The mobile and location-based technologies in *Frequency 1550* made it possible to provide an authentic learning environment and foster learning outside of traditional formal educational settings. The authors suggested further research to focus on which element of the game contributes to learning: were successful results attributable to the game's digital features or to its location technology?

Islas Sedano and Leendertz (2013) claimed that learning took place the moment that students were engaged and that the game *LIEKSAMYST* bridged the informal and formal aspects of learning. Student engagement in solving problems and conquering challenges was merged with emotions and historical facts in the game, which directly benefited students in the learning process. The authors indicated that teachers and curators could take advantage of this possibility to support, encourage, and develop learning.

Ke and Abras (2013) reported that reduced engagement led to a decreased level of active processing of math content. In the math game *Ker-Splash*, students' acquisition of math content showed a decline when they had less engagement. This study highlighted the importance of designing learner-adaptive engagement and a balanced integration of math content and gameplay. The authors suggested that educational designers and practitioners on educational game design should take learners' diverse characteristics and needs into consideration in order to maintain a high level of engagement.

Lowrie, Jorgensen, and Logan (2013) demonstrated that engagement with the game *The Legend of Zelda: Phantom Hourglass* fostered students' ability in reading and interpreting maps. They also indicated that game playing could be a catalyst for further learning outside of the game experience. The students who played the game showed improved reading competence. The authors suggested that the game triggered an awareness of real-world settings and could be explored more.

Pontual Falcão et al. (2018) identified engagement in *DEMULTS* as a key component to promote learning. Specifically, they claimed that learning did not occur and tangible goals cannot be achieved without engagement in educational games. They pointed out that it was fundamental to keep learners engaged in game-based learning and suggested future research to identify how individual needs can be better met to sustain engagement and improve education.

Rowe et al. (2011) concluded that there were significant relationships between microbiology post-test scores and two measures of engagement, presence and situational interest. In the game *CRYSTAL ISLAND*, student engagement with the game environment was associated with improved learning outcomes and in-game problem-solving. The study found a strong positive relationship between learning outcomes, in-game problem-solving, and increased engagement. Furthermore, the relationship between learning outcomes and engagement remained even when controlling for students' background knowledge and game-playing experience. A possible explanation could be that the association between engagement and learning is motivational in nature. The authors pointed out that additional investigation was needed to determine which elements of the game-based learning were most closely associated with learning and engagement. These efforts would contribute to the development of models to automatically detect student engagement and learning.

Riemer and Schrader (2016) found that, in the educational game *Cure Runners*, the more the participants were engaged in self-monitoring behavior, the more accurate their mental models became. Their study contributed to the understanding of how learners can develop accurate models through playing an educational game for acquisition of complex cognitive skills. The researchers recommended future studies investigating factors that affect mental model development in serious games.

Sabourin and Lester (2014) demonstrated that there was a positive correlation between engagement, capacity for inquiry, and problem-solving ability. In the game *CRYSTAL ISLAND*, students who exhibited strategies relating to inquiry and problem-solving had more effective outcomes and engagement. Off-task behaviors were observed among disengaged students and were negatively correlated with learning gains. Superfluous features of game-based learning may distract students; however, the rate of off-task behaviors observed during *CRYSTAL ISLAND* was not significantly higher than that of other educational games. The authors directed future research to compare engagement and learning in game-based learning and traditional settings.

Vasalou et al. (2017) found that social engagement created new opportunities for learning. In *Words Matter*, engagement with mini-games exposed children's ability levels and posing identity threats to children. The researchers also highlighted that engagement in the context of personalized games tended to create salient personal identities, which may act as a barrier for collaborative learning. Thus, they suggested an investigation of how engagement works differently on personal learning and collaborative learning levels in future studies.

Summary

This section amalgamated study results about the connection between student engagement and learning outcomes in game-based learning. Eleven of the thirteen studies indicated that there was a relatively positive connection between engagement and learning. Some of these identified that engagement in game-based learning produced learning gains or promoted positive learning outcomes. Others only stated that there was a positive relationship between engagement and learning. In summary, game-based learning engages student in gameplay and solving problems, which in turn, impacts student learning outcomes. However, there are two studies that found no relationship or a negative relationship between engagement and learning, which should raise instructional game designers' attention. Too many entertainment features may distract students and hinder learning.

RESEARCH ISSUES

This section focuses on discussing research designs in the empirical studies reviewed in this report. Scholars used various approaches to measure student engagement and designed different studies to address their research questions. First, scholars used various combinations of measurement tools to calculate student engagement and learning outcomes, including log data, observations, surveys, and self-reports. Secondly, researchers employed different designs to study student engagement in game-based learning by adding treatment in experiments. Experimental design encompasses the comparison of pre-test and post-test scores, game group and control group, and different game feature settings, correlational research design, predictive research design, and case study.

Measurement of student engagement and learning outcome

Fredricks et al. (2004) concluded that observer ratings and self-report surveys of behavioral engagement were useful tools for measurement. Most of the studies measuring emotional engagement used self-reports, which included survey items about a variety of emotions relating to game, tasks, and challenges. Approaches to measuring cognitive engagement were limited. In the studies reviewed by this report, various instruments were used to measure student engagement and their learning outcomes, including log data, self-reports, observations, and surveys.

Log data

Filsecker and Hickey (2014) analyzed the number of screens of formative feedback that students accessed with the help of log files. They analyzed the extent to which students interacted with the scientific and ecological discourse. Vasalou et al. (2017) recorded students' gameplay and the logs comprising the time played, ratio of success, number of words played, and students' model entries in the game *Words Matter*.

Observations

Participant observation enables researchers to observe student groups or individuals and their activities. It requires a systematic description of all the events being observed. There were two types of observation identified by this report from empirical studies: on-site observation and videotaping observation. Scholars used on-site observation in classroom settings and used this method when research participants were in remote locations. Ke and Abras (2013) observed students' game-playing activities in classrooms. They analyzed student behaviors by following a protocol that was anchored in the GameFlow and RETAIN models. Annetta et al. (2009) performed classroom observation to investigate student engagement with the game *MEGA* and then coded student engagement on a 0-4 scale. Score-rating consisted of a double-rating procedure to improve reliability. Vasalou et al. (2017) conducted the video analysis as researcher-observers. In *Words Matter*, students' dialogue and interaction with each other were observed. Then, the authors generated codes for patterns of students' verbal and non-verbal behaviors. Pontual Falcao et al. (2018) videotaped students' activities, focusing not only on the relevance of the different aspects of the activities, but also on how those aspects were organized when students were engaged in the game.

Surveys

Pontual Falcao et al. (2018) distributed questionnaires to novices that covered various topics including personal interests, life goals, expectations, and reasons for interest in the project. Islas Senado and Leendertz (2013) focused on student engagement with the museum and the objects within *LIEKSAMYST* through questions to measure student cognitive and emotional engagement. Example questionnaire items were “I feel happy when playing *LIEKSAMYST*” and “When playing the game, I became more interested in knowing more about historic content.” The authors also asked students questions to measure their learning outcomes. Hamari et al. (2016) sent out a psychometric survey to measure the level of participants’ subjective experience of challenge, skills, engagement, and perceived learning.

Self-reports

Allen et al. (2014) collected student self-reports at pre-test, before and during each training session, and finally at post-test in their study of the game *Writing Pal*. The self-reports helped researchers assess student writing ability in addition to students’ attitudes and motivation. Coller, Shernorf, and Strati (2011) required students to complete an Experience Sampling Form (ESF) to report their in-game experience and the nature of the activities that they were engaged in.

Different research design methodologies

Pre- and post- experiments

To measure students’ in-game action, Rowe et al. (2011) gave students curriculum tests and two questionnaires testing interest and presence. Students received the same curriculum test before and after the experiment. The difference between pre- and post-scores showed their learning outcomes. The in-game measures included quizzes, character interactions, mystery solution, and a final score generated by *CRYSTAL ISLAND*. After being exposed to *CRYSTAL ISLAND*, students who were more engaged in the game achieved greater learning outcomes. Coller, Shernoef, and Strati (2011) also gave students the exact same Experience Sampling Form (ESF). Students completed the form several times before, during, and after the intervention. As the experiment lasted for multiple years, participants did not complete the form with a high level of frequency.

Annetta et al. (2009) conducted a pre-test to ascertain students' prior knowledge before playing *MEGA* and a post-test after the conclusion of their participation. This method was meant to determine whether students attained learning gains after playing *MEGA*. The results suggested significant gains from pre-test to post-test.

Allen at al. (2014) gave students a one-hour pre-test including individual difference measures: demographics survey, writing proficiency, reading comprehension ability, vocabulary knowledge, writing attitude, and writing strategy knowledge. During the last session, a post-test was given to students. This post-test included a writing proficiency test, a writing attitude survey, and a writing strategy knowledge survey, which was similar to the pre-test. The measures assessed students' changes during the training.

Before the experiment investigating the *McLarin's Adventures* game, the students received a pre-test in which they were challenged to construct a solution to a complex scenario. After the one-year intervention, they were again asked to come up with a solution to a complex scenario. The changes that occurred between the pre-test and post-test reflected students' learning outcomes. Eseryel et al. (2014) concluded that students' problem-solving ability was impacted by game-based learning.

A set of mini-knowledge tests including a pre-test and a post-test was developed to measure the effectiveness of the game (Ke & Abras, 2013). The testing items were extracted from the math concepts relating to the game. Results showed that game-based learning supported students with special learning needs.

Students completed a series of pre-study questionnaires including a test of prior knowledge and several measures of personal attributes a week before the intervention. During the study, students interacted with *CRYSTAL ISLAND* for 55 minutes or until they completed the mystery. Immediately after completing the interaction, students were given a post-test with questions identical to the pre-test. Sabourin and Lester (2014) stated that game-based learning environments offered significant potential for increasing students' learning outcomes.

Riemer and Schrader (2016) gave students an online questionnaire after providing information about *Cure Runners*. After the questionnaire, the pre-gaming measures were obtained. Post-gaming measures (analogous to the pre-gaming measures) were obtained after the gaming sessions. The study found that the more the participants engaged in self-monitoring behavior, the more accurate their mental models became.

Game-based setting vs. traditional setting

Shaaf (2012) assigned students randomly into the control and experimental groups. The control group received an altered lesson using a different instructional strategy, while students in the experimental group received digital game-based learning. Students in both groups were observed, and their time-on-task behavior was recorded. Six out of eight trials showed higher average levels of enjoyment, focus, and attentiveness among students in the game-based setting than among students in the traditional setting.

Annetta et al. (2009) employed a quasi-experimental study design in which the treatment group played a game, *MEGA*. The students involved in the study were from four classes who all took a high school biology course from the same teacher. In the experimental group, *MEGA* was introduced to students as a material for review of a genetics unit. Students played MEGA in pairs using the desktops in school computer labs. In the control group, students revised the unit through independent paper and pencil practice and discussed it in groups. The researchers stated that there were significant differences between groups in terms of participants' engagement.

Chang et al. (2016) chose five classes for their study. One class, in which students learned fractions using paper-and-pencil drills, was assigned as a control group. The other four classes learned fractions by playing the game *APP* on iPod Touches. Overall engagement and three sub-domains of engagement were examined after ten sessions of treatment. The results showed that student engagement was slightly higher in the experimental group, and lower in the control group.

Huizenga et al. (2009) used a quasi-experimental design to study the effects of a mobile city game called *Frequency 1550*, which was designed to educate students about history of medieval Amsterdam. Students in ten classes played the game while the students in the other ten classes received a regular lesson. The scholars stated that participants in the experimental group were more engaged and gained significantly more knowledge than those in the control group.

Different game feature design

Filsecker and Hickey (2014) used a quasi-experimental design to examine the effect of rewards in one group compared to a control group with the game *Quest Atlantis*. The purpose of the study was to investigate whether individuals who received rewards showed a deeper engagement with the learning activities. However, the results showed no significant difference between groups.

Ronimus et al. (2014) also conducted a study to determine whether a rewarding system had effects on student engagement and learning outcomes. Students played with *GraphoGame* at home under the supervision of parents, and their data were stored in the online server. The results showed that the rewarding system seemed to encourage student engagement in the beginning, but the effect vanished after a few sessions. The authors suggested further studies to investigate the effectiveness of game features for maintaining student engagement.

Predictive research design

Harami et al. (2016) used two different games in their study: *Spumone* and *Quantum Spectre*. In their study, engagement was a superordinate construct composed of the interest, enjoyment, and concentration constructs. Students were asked two to three items as indicators for each of the constructs: concentration, enjoyment, interest, challenge, skill, immersion, and perceived learning. The results showed that the level of challenge in the game was a strong predictor of learning outcomes. Skill did not affect learning directly, but it did increase engagement in the game.

Correlational research design

Islas Sedano and Leendertz (2013) gathered information from 101 students and analyzed the data using a quantitative method guided by a qualitative interpretational approach. The scholars confirmed that there was a significant correlation between fantasy and engagement. This study highlighted the importance of evoking emotional and cognitive engagement in the games.

Case study

Lowrie et al. (2013) employed a two-phase design in their study. In the first phase, a survey was sent to students to identify their gaming habits and the types of math-related games they played. In the second phase, participants were selected to conduct case studies. Case study participants were asked questions by interviewers. Results showed that there were distinct differences in the approaches to engage students in games and to contextualize game-based learning within students' knowledge and experiences.

Vasalou et al. (2017) adopted a qualitative case study approach in their research design. All of the participants were diagnosed with dyslexia. They played the game *Words Matter* for three weeks with facilitation by tutors. Students' logs of game play were recorded, and observers conducted an analysis of the videos. Results showed that students were engaged in "game talk" regarding game performance, content, actions, and experience.

Summary

This section described various methods to measure engagement and learning. Different research designs were included as well. From the research findings, first, there was not a unified way to measure engagement and learning. The measurement methods included referring to log data, observations, surveys, and self-reports. Researchers often used at least two of these methods to measure student engagement and/or learning. Mixing various types of measurement potentially has the benefit of greater predictive power; the key is to ensure that the combination is dedicated to understanding each type of engagement. Second, research design varied significantly between studies: pre- and post-experiment, game-based setting vs. traditional setting, different game features, correlational research design, predictive research design, and case study. With the help of these strategies, researchers were able to differentiate game-based learning from other instructional methods and then study its effects on student engagement and learning. The majority of studies reviewed by this report used the design of comparing students' pre-test and post-test scores to examine learning gains in game-based learning. Eight out of twenty studies collected and analyzed pre-test and post-test data. They calculated the difference or changes between the initial student scores and the scores students achieved after playing games. Although other research designs were not utilized as often, they suited the research needs and helped researchers conduct the studies. Overall, the results can provide insights for education researchers about how to design their studies.

Chapter 4: Conclusion and Future Directions

This report has reviewed the empirical studies that examined student engagement in game-based learning from 2008 to 2018. A total of 20 studies were included. The sample of students' education levels ranged from K-12 to college. The research sites were spread over the U.S., Taiwan, Australia, and Europe. The findings showed that student engagement in game-based learning was a topic where research results conflicted, demonstrating a need for future examination. The two research questions of this review were discussed in Chapter 3.

To answer the first research question—which factors affect student engagement in game-based learning—the report synthesized the findings from empirical studies. The factors being examined were: relatedness, frequency, competence/skill, gender, enjoyment, interest, self-efficacy, autonomy, control, challenge, presence, fantasy, social interaction, task characteristics, rewards, and technical problems. Those factors have varying influences on student engagement in game-based learning. This report took a close look at the consistency and inconsistency of empirical study findings. Most of the studies have confirmed that certain factors, including fantasy, self-efficacy, control, presence, and task characteristics, would influence student engagement in game-based learning. To better engage students in game-based learning, game designers and educators may want to pay attention to factors that have positive effects on students' engagement and minimize the effects of factors that negatively impact it.

Regarding the second research question about the connection between student engagement and learning in game-based education, most of the studies reviewed in this report found a positive relationship between engagement and learning. The researchers of those studies stated that game-based learning engaged student in gameplay and solving problems and thereby increased student learning outcomes. Only two studies found no relationship or a negative relationship between engagement and learning. Game designers and instructional game designers should consider one possible reason for disengagement: the presence of too many entertainment features in a game may distract students and worsen learning outcomes.

In the literature review report, some measurement and research design issues were identified when analyzing the 20 studies done in the past ten years. To avoid those problems, this report also proposes future directions for researchers as follows.

As mentioned earlier in this report, student engagement is a multifaceted and complex construct measured by three dynamically interrelated dimensions. The attempt to study portions of the concepts under the label of "engagement" could lead to proliferating research on constructs and definitions. Even though there has been substantial research on how students behave, feel, and think, the three subdomains of engagement overlap with each other, and some factors affect constructs that stand at the intersection of two subdomains. Thus, future research should pay attention to improving clarity. This report recommends that future researchers be aware of the definition of student engagement and specify which subdomains of engagement will be studied in their examinations.

Student engagement in game-based learning has been explored in elementary schools, middle schools, high schools, and colleges. However, the studies have not been spread equally over the four age ranges. For example, more studies were conducted in elementary schools than in colleges. The reason for the unevenness of studies in different age ranges was not discussed in this study; further research could examine this question. In addition to that, student engagement is likely to take different forms between elementary schools and colleges. Studies found steep declines in school engagement across the grade levels (Eccles, Midgley, & Adler, 1984). The composition of behavioral, emotional, and cognitive engagement varies by student age. Future studies could be conducted to understand different types of engagement among different age groups.

For data collection, scholars should consider how collection methods may affect the validity of data. Student learning outcomes were examined by many types of measurement methods: log data, observations, surveys, and self-reports. This report did not evaluate or rank the efficiency of these methods. Researchers should select appropriate data collection methods by taking into consideration their sample age and experiment environment. When using log data in particular, researchers are encouraged to consider using data mining techniques to evaluate and anticipate student learning outcomes and behaviors.

For research design, future research could learn from the empirical studies surveyed in this report: pre- and post- experiments, game-based setting vs. traditional setting, different game features, and non-comparing group studies. To differentiate game-based learning from other instructional methods, all of the above strategies are recommended for quantitative studies of student engagement and learning. Case studies and interviews can help researchers collect deep information.

This report did not intend to undertake a comprehensive discussion about how factors affect student engagement in game-based learning and how engagement affects learning from psychological perspective. Rather, this report has focused on analyzing common research patterns and reporting the findings that have been examined. More research studies about this topic are expected in the near future.

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