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Game-based Learning and 21st century skills: A review of recent research

Meihua Qian[*], Karen R. Clark

Eugene T. Moore School of Education, Clemson University, United States

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ABSTRACT

Game-based learning and 21st century skills have been gaining an enormous amount of attention from researchers and practitioners. Given numerous studies support the positive effects of games on learning, a growing number of researchers are committed to developing educational games to promote students' 21st century skill development in schools. However, little is known regarding how games may influence student acquisition of 21st century skills. This paper examines the most recent literature in regard to game-based learning and identified 29 studies which targeted 21st century skills as outcomes. The range of game genres and game design elements as well as learning theories used in these studies are discussed, together with the range of indicators, measures and outcomes for impacts on 21st century skills. The findings suggest that a game-based learning approach might be effective in facilitating students' 21st century skill development. The paper also provides valuable insights for researchers, game designers, and educators in issues related to educational game design and implementation in general.

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1. Introduction

Trends in educational research indicate an increasing interest in how games may influence learning (e.g., Ke, 2009; Kebritchi, Hirumi, & Bai, 2008; Wu, Chiou, Kao, Hu, & Huang, 2012b). To date, a number of literature reviews have been conducted regarding the effectiveness of game-based learning in various domains such as business, math, statistics, computer science, biology, and psychology (e.g., Boyle et al., 2014; Connolly, Boyle, MacArthur, Hainey, & Boyle, 2012; Dempsey, Rasmussen, & Lucassen, 1994; Emes, 1997; Randel, Morris, Wetzel, & Whitehill, 1992; Vogel et al., 2006; Wolfe, 1997; Wu et al., 2012b). However, no consensus has been reached in respect to the positive effect of game-based learning. For example, some studies (e.g., Boyle et al., 2014; Dempsey et al., 1994; Randel et al., 1992; Vogel et al., 2006) pointed out that game-based learning might be superior to traditional classroom instruction as it could increase students' motivation for learning and provide them with opportunities to explore and acquire new knowledge and skills, but others (e.g., Emes, 1997) did not find strong evidence which supports the association between game-based learning and students' high academic achievements or psychological development.

Furthermore, most of the previous literature reviews (e.g., Connolly et al., 2012; Emes, 1997; Ke, 2009; Randel et al., 1992; Wolfe, 1997; Wu et al., 2012b) focused on the statistical significance of empirical studies and rarely emphasized their practical significance (i.e., effect size), though the latter is much more informative than the former. Specifically, any test with a large sample size tends to be statistically significant, yet it might not be practically meaningful. Hence, game-based learning may not be more effective than conventional classroom lectures if the comparison appears statistically significant but the corresponding effect size is tiny.

Most importantly, a few studies have indicated that a growing number of researchers are committed to developing educational games to support the teaching of essential 21st century skills (e.g., Boyle et al., 2014; Dondlinger, 2007). However, little is known regarding how game-based learning may influence students' 21st century skill development (Ebner & Holzinger, 2007; Ke, 2009; Kim, Park, & Baek, 2009; Papastergiou, 2009; Van Eck & Dempsey, 2002). The 21st century skills refer to a wide range of skills such as learning and innovation skills (i.e., critical thinking, creativity, collaboration, and communication) and information, media and technology skills (Binkley et al., 2014), and have been gaining more and more attention from researchers and

* Corresponding author. Eugene T. Moore School of Education, Clemson University, 410 Tillman Hall, Clemson, SC 29634, United States.
E-mail address: mqian@clemson.edu (M. Qian).

practitioners (e.g., Chan & Yuen, 2014; Gee, 2007). For instance, the current school curriculum in Hong Kong clearly emphasizes the importance of students' creativity development, and as a result, teachers are encouraged to develop or adopt innovative teaching methods to foster students' creativity in the classroom (Chan & Yuen, 2014). But at this point, no model exists as to how to best teach the core 21st century skills in schools.

Game design and play require people to be familiar with media and technology, and it also requires people to be creative and critical thinkers, so it has great potential to facilitate students' 21st century skill development. Given the lack of consistent empirical evidence with respect to the effectiveness of game-based learning, this review aims to examine the most recent literature regarding game-based learning and seeks to further understand the influence of games on learning, with a major focus on students' 21st century skill development.

2. Literature review

2.1. Definition of game-based learning

Game-based learning (GBL) describes an environment where game content and game play enhance knowledge and skills acquisition, and where game activities involve problem solving spaces and challenges that provide players/learners with a sense of achievement (e.g., Kirriemuir & McFarlane, 2004; McFarlane, Sparrowhawk, & Heald, 2002; Prensky, 2001).

2.2. Evidence of impact and outcomes for games in education

Previous reviews indicate that the most frequent outcome investigated in educational game studies was knowledge acquisition (Connolly et al., 2012; Li & Tsai, 2013) with less than one-third of the studies investigating problem solving skills (Li & Tsai, 2013), and affective and motivational outcomes were examined more frequently in entertainment game studies (Connolly et al., 2012). Although educational game studies reveal varying degrees of success dependent upon academic topic, learner preferences and participant age (Hays, 2005; Young et al., 2012), GBL tends to positively influence attitudes and cognitive gains (Connolly et al., 2012; Dempsey et al., 1994; Hays, 2005; Vogel et al., 2006; Wolfe, 1997; Young et al., 2012). But there is a dearth of high quality empirical evidence concerning how games in the classroom might impact the development of 21st century skills.

Skills relevant to the 21st century are dramatically different from skills the educational system currently values (Squire, 2005). The 21st century learning and innovative skill set is defined as critical thinking, creativity, collaboration and communication (Binkley et al., 2014). Critical thinking skills include scientific reasoning, systems thinking, computational thinking, decision making and problem solving (Binkley et al., 2014). Creativity includes divergent thinking, innovative thinking, originality, inventiveness and the ability to view failure as an opportunity to improve (Binkley et al., 2014). Collaboration pertains to the ability to work effectively and respectfully with diverse teams, exercise flexibility and willingness to make compromises to accomplish goals, and assume shared responsibility (Binkley et al., 2014). Communication refers to the ability to articulate thoughts and ideas in a variety of forms, communicate for a range of purposes and in diverse environments, and use multiple media and technologies (Binkley et al., 2014). Traditional educational practices often hinder creativity by emphasizing only one correct answer, imposing high-stakes failure, and favoring conformity and standardization (e.g., Plucker & Makel, 2010). Additionally, 21st century skills are difficult to evaluate using traditional assessment practices such as the popular standardized

testing (Binkley et al., 2014). Games, on the other hand, necessitates the development of 21st century skills which are valued in the new digital economy (Gee, 2008; Squire, 2011; Van Eck, 2012) and provide a means of assessing these hard to evaluate skills (Shute, 2011). Specifically, effective learning is situated, active, and problem-based and requires immediate feedback (e.g., Boyle, Connolly, & Hainey, 2011). Well-designed educational games such as Quest Atlantis (Barab et al., 2009) and The Radix Endeavor (MIT, 2014) provide complex holistic problem-based environments that can support active and situated learning, require authentic collaboration, and offer challenge and immediate feedback (Gee, 2007; Squire, 2011). However, a systematic review of the impact of games on 21st century skill development is needed.

2.3. Designing games for education

2.3.1. Game design elements and meaningful learning

Very little is known as to what degree of design complexity is required for meaningful learning to occur (Hays, 2005; Young et al., 2012). Many educational games are simple designs that are narrowly focused on academic content, target low level literacy, provide drill and practice methods similar to worksheets, and stress memorization of facts (Squire, 2003; Villalta et al., 2011; Young et al., 2012). These game designs fail to engage students (Lester et al., 2014; Squire, 2003).

Meanwhile, research has showed that entertainment games are able to promote meaningful learning through providing players with adaptive challenge, curiosity, self-expression, discovery, immediate feedback, clear goals, player control, immersion, collaboration, competition, variable rewards, and low-stakes failure (e.g., Anderson, 2011; Gee, 2007; Squire, 2011). All these game design elements align well with established learning theories such as social constructivism and flow theory. Therefore, these types of games can provide situated learning, promote social interactions, increase motivation and engagement, and provide opportunities to develop valued 21st century skills (e.g., collaboration, creativity, communication, critical thinking) (Anderson, 2011; Csikszentmihalyi, 1990; Gee, 2007; Shute, 2011; Squire, 2011). However, designing games for specific educational purposes presents an interdisciplinary challenge as it requires a deep understanding of game design theory, knowledge of the academic topic, and a foundation in relevant learning theories (e.g., Boyle et al., 2011).

2.3.2. Learning theories and successful game designs

Meaningful learning will not take place without learners' investment of time and effort. Popular entertainment games maintain players' engagement by employing "every single worthwhile learning theory in existence" (Becker, 2007, p.23). Yet, GBL studies often fail to use theoretical foundations (e.g., Li & Tsai, 2013; Wu, Hsiao, Wu, Lin, & Huang, 2012a; Wu et al., 2012b). For example, Wu et al. (2012b) reviewed 567 published studies and found that GBL tended to yield positive outcomes when learning theories were incorporated into the design, but surprisingly most studies did not address learning theories. According to Young et al. (2012), successful GBL is not simply providing students with a game and expecting increased motivation and knowledge acquisition, "Rather, educational games need to be designed and researched with careful attention to contemporary learning theories" (Young et al., 2012, p.68).

The sociocultural theory of learning (Vygotsky, 1978) and flow theory (Csikszentmihalyi, 1990) align well with successful game designs and learning outcomes. Vygotsky (1978) states that learning takes place when it is social, active and situated. Also, play is conducive to learning (Vygotsky, 1978). Gamers interact in role