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

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

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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
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; Villaalta 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
playing environments that allow them to explore social roles (inside and outside of the game), form hypotheses, test new ideas, and develop skills by playing (Gee, 2005; Squire, 2005; Tennyson & Breuer, 2002). Twining (2009, 2010) has outlined a modern pedagogy that includes dimensions of 'learning by being told', 'learning by doing', 'learning through role play', and ultimately 'learning by becoming'. Many successful entertainment games provide incredibly realistic and immersive environments where gamers can learn through role play experiences. These games can provide a successful design model for digital GBL.

Also, flow theory is a natural foundation for motivation in games and learning. Flow causes the player to lose time and goal-directed activity is driven by pure pleasure rather than external rewards (Csikszentmihalyi, 1990). Entertainment game designers balance the game’s challenge level with the player’s skill level to create and maintain flow. However, many educational games interrupt the state of flow by inserting content and content assessment via quizzes and tests (Shute, 2011). Successful game designers utilize internal analytics to collect data on the gamers, adapt challenges to maintain flow, and provide timely feedback. Educational games can implement this model so that learning via game play can continue fluidly while assessments are conducted inconspicuously and so that flow is maintained (Shute, 2011).

According to Li and Tsai (2013), constructivism (e.g., the socio-cultural theory of learning) is one of the major theoretical foundations employed by GBL researchers in science education. The present study will examine the learning theories that are utilized in GBL related to the 21st century skill development.

3. Method

3.1. Search terms and database searched

A keyword search was conducted using Academic Search Complete which is the most comprehensive scholarly, multidisciplinary database in the world and covers all subject areas from 1965 to present. Since technology advances at a rapid pace and this review aims to examine the most recent literature regarding game-based learning, the date range was restricted from January 1, 2010 to December 31, 2014, and the following keywords were used: (“serious game”) OR (“game-based learning”) OR (“design-based learning”) OR (“educational game”) OR (“video game”) OR (“augmented reality”) OR (“entertainment game”) OR (“mobile game”) OR (“ubiquitous learning”) OR (“massively multiplayer online role playing games”) AND (“learning”) OR (“education”) OR (“behavior”) OR (“skills”) OR (“21st century skills”). This search resulted in 3118 articles.

3.2. Selection of papers for inclusion in the review

Articles from the following six journals were chosen as a representative sample of recent research on GBL: Computers & Education; Computers & Human Behavior; Information Sciences; Journal of the Learning Sciences; Learning and Instruction; and British Journal of Education Technology. The resulting 397 articles were analyzed by two raters to identify appropriate papers for this review, and 137 studies met our inclusion criteria.

To be included in this review, papers had to (a) include evidence related to digital technology enhanced learning environments; (b) include quantitative statistics with effect size being or not being reported; and (c) date from January 1, 2010 to December 31, 2014. The Cohen’s Kappa statistic was used to examine the interrater reliability. According to Cohen (1960) and McHugh (2012), our interrater reliability was high (κ = 0.82), and we resolved all disagreements to consensus through discussion.

3.3. Data analysis

The 137 papers meeting the initial inclusion criteria were analyzed to explore potential influences of digital games on learning, especially on student acquisition of 21st century skills.

3.3.1. Categorization of games

Categories were defined based on the primary purpose of the game. Educational games and serious games are games developed specifically for educational purposes. Commercial off the shelf, console games (video games), and online games (massively multi-player online role playing games) are categorized as entertainment games. Games-based learning is a common term with broad interpretations and can include educational games, edutainment, or entertainment games. Therefore, papers whose research design specified games-based learning were further categorized based on the specific game or instrument used in the study (education, entertainment, or non-game). Design-based-learning studies utilized games with a design focus rather than playing the game. These studies may have students designing a digital product such as digital story telling or using visual coding tools to design games. It was decided to make design-based games a category since the premise of the game is unique. Although this literature review aimed to investigate games for learning, our search returned a number of studies which focused on mobile tools. These mobile tools are considered games, or not, based on the specific design of that tool. Mobile tools designated as a mobile game and mobile augmented reality/context aware were categorized as mobile (AR).

3.3.2. Categorization of outcomes

Outcomes were categorized as 21st century skills (critical thinking, creativity, communication, and collaboration), cognitive (retention, transfer, cognitive load, and knowledge acquisition), skills (motor, spatial, and visual skills) or behavioral (behaviors and attitudes).

3.3.3. Categorization of ages

Age groups were determined based on the American education system, with elementary school including K-5 (5–11 years old), middle school as grades 6–8 (12–14 years old), high school being grades 9–12 (15–18 years old), and higher education including community college and university (undergraduate and graduate levels). Adults refer to participants who are no longer in school such as employees in a company.

3.3.4. Categorization of effect sizes

The conventional criteria were used to categorize the effect sizes
reported in the primary studies, which included correlation measure \( r \), Cohen’s \( d \), and partial eta-squared (\( \eta_p^2 \)). Specifically, according to Cohen (1988), a correlation coefficient of 0.10 is small, 0.30 is medium, and 0.50 is large. The corresponding thresholds for standardized mean difference (i.e., Cohen’s \( d \)) are 0.20, 0.50 and 0.80 (Cohen, 1988). For partial eta-squared, the thresholds for small, moderate and large are 0.01, 0.06 and 0.14 (Cohen, 1988; Miles & Shevlin, 2001).

4. Results

4.1. General findings

Fig. 1 suggests an overall upward trend in quantitative game-based learning research.

The 137 papers identified for review were diverse with respect to game genres, participant ages, and learning outcomes. Specifically, participants in these studies covered a wide range of ages. The majority of the studies investigated higher education (30%), followed by middle (21%), elementary (20%) and high school (13%) age, and adults (9%). Several studies did not specify age of participants since the research design surveyed online game communities (8%).

Various game genres were used in the studies. Most of the papers (50%) used an educational game, and the rest used entertainment games (25%), mobile augmented reality or mobile games (15%), design-based games/tools (7%), and intelligent tutoring systems, gamification or other digital technologies (4%).

A wide variety of learning outcomes were investigated. As every paper discussed multiple learning outcomes, the outcomes are reported as percentages. The majority of the studies included some behavior(s) as learning objectives (42%). Other outcomes investigated were cognitive (38%), 21st century skills (13%) and skills (7%). A total of 29 papers (21%) investigated 21st century skills.

4.2. Game-based learning and 21st century skills

4.2.1. Learning outcomes

Twenty-nine papers reported the influence of games on the development of 21st century skills, with the majority focusing on critical thinking skills (Fig. 2). Only one of the articles considered communication as a learning outcome, although it is an essential 21st century skill (Binkley et al., 2014).

4.2.2. Age groups

Participants’ age in the 29 papers analyzing games-based learning for 21st century skill development ranged from elementary school age to adult. The majority of the papers focused on higher education (27%) and middle school (27%), followed by elementary school (20%) and high school (13%) and adults (10%) and undisclosed (3%).

4.2.3. Learning theories

Analysis of the 29 studies investigating 21st century skills development using GBL reveals that the majority of the studies (76%) explicitly referenced at least one established learning theory in the research design and/or in the game design (Table 1), with constructivism being the most popular one, and a variety of other learning theories (e.g., constructionism and flow theory) being used as foundations for the research design or the game design.

4.2.4. Game design elements

Further analysis of the 29 studies indicates that game design elements were specifically targeted in the choice of game, and most studies (90%) included more than one game design element. Additionally, half of the studies utilized pre-existing games (video games, serious games, simulations, augmented reality and design focused games), and the rest designed a game specific to their study. Table 2 displays the distribution of all the game design elements, with collaboration, role playing, narrative, exploration, and complexity being the most popular ones.

4.2.5. Effect sizes

Twenty nine papers investigating the effects of GBL on 21st century skills reported a total of 97 outcomes, with 85% of the results being significant (i.e., \( p < 0.05 \)), and roughly one-third (34%) being associated with medium to large effect sizes (Fig. 3).

4.2.6. Game genres and effect sizes

Table 3 shows very few entertainment game-related studies investigated 21st century skills as learning outcomes, and most studies which reported moderate to large effect sizes employed either educational games or design-based learning. Also, six papers (21%) used mobile games, yet no effect sizes were reported.

4.2.7. Game-design elements and effect sizes

Additionally, Table 4 displays the relationship between game design elements implemented in the 29 studies and the practical significance of the empirical findings. Collaboration, competition, complexity, exploration and discovery, role play, self-expression and interactivity tended to be associated with moderate or large effect sizes.

An in-depth examination of a total of 13 studies which reported both significant results and effect sizes reveals that these studies
focused on GBL and critical thinking skills (e.g., Akcaoglu & Koehler, 2014; Vos et al., 2011; Yang & Chang, 2013; Yang & Wu, 2012a; Yang, 2012b), and rarely targeted other 21st century skills such as creativity and collaboration as learning outcomes.

For example, Yang (2012b) used an entertainment game to investigate the effectiveness of GBL with an emphasis on constructivism learning theory and five game design elements (i.e., exploration, discovery, competition, collaboration, and low stakes failure). Results found that playing the game significantly improved participants’ problem solving skills (partial \( r^2 = 0.14 \)).

Vos et al. (2011) compared design-based learning and GBL. The study was founded in constructivism theory and focused on game design elements of role playing, interactivity, collaboration and competition. Students designing their own games were significantly more interested (Cohen’s \( d = 1.09 \)) and exhibited deeper strategy formation (Cohen’s \( d = 1.07 \)) than students who only played the game. Students in the design group also expressed significantly more interest in the game design elements of role playing, interactivity, collaboration and competition. Students designing their own games were significantly more interested (Cohen’s \( d = 1.09 \)) and exhibited deeper strategy formation (Cohen’s \( d = 1.07 \)) than students who only played the game. Students in the design group also expressed significantly more interest in the game design elements of role playing, interactivity, collaboration and competition.

Table 1
Learning theories implemented in game-based learning studies.

<table>
<thead>
<tr>
<th>Learning theory</th>
<th>Count of Papers</th>
<th>Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constructivism</td>
<td>13</td>
<td>Ahmed and Parsons (2013); Barzilai and Blau (2014); Chang, Chen, and Hsu (2011); Charitonos, Blake, Scanlon, and Jones (2012); Chiang, Yang, and Hwang (2014); Hamalainen and Oksanen (2012); Hou and Li (2014); Lan, Tsai, Yang, and Hung (2012); Robertson (2012); Vos, van der Meijden, and Denessen (2011); Yang and Wu (2012a); Yang (2012b); Yang and Chang (2013)</td>
</tr>
<tr>
<td>Constructionism</td>
<td>4</td>
<td>Akcaoglu and Koehler (2014); Ke (2014); Hou and Li (2014); Liu, Cheng, and Huang (2011)</td>
</tr>
<tr>
<td>Activity theory</td>
<td>2</td>
<td>Dzeng, Lin, and Wang (2014); Ryu and Parsons (2012)</td>
</tr>
<tr>
<td>Experiential &amp; generative learning</td>
<td>2</td>
<td>Ranchhod, Gurau, Loukis, and Trivedi (2014); Pasin and Giroux (2011)</td>
</tr>
<tr>
<td>Flow theory</td>
<td>2</td>
<td>Hou and Li (2014); Ryu and Parsons (2012)</td>
</tr>
<tr>
<td>Cognitive theory</td>
<td>1</td>
<td>Johnson and Mayer (2010)</td>
</tr>
<tr>
<td>Narrative centered learning</td>
<td>1</td>
<td>Lester et al. (2014)</td>
</tr>
<tr>
<td>Scientific discovery as duel search model</td>
<td>1</td>
<td>Lazonder, Hagemans, and de Jong (2010)</td>
</tr>
<tr>
<td>Situated learning theory</td>
<td>1</td>
<td>Hou and Li (2014)</td>
</tr>
<tr>
<td>Uses &amp; gratification theory</td>
<td>1</td>
<td>Reychav and Wu (2014)</td>
</tr>
</tbody>
</table>

Table 2
Game design elements implemented in game-based learning study.

<table>
<thead>
<tr>
<th>Game design element</th>
<th>Count of Papers</th>
<th>Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collaboration</td>
<td>8</td>
<td>Chiang et al. (2014); Hamalainen and Oksanen (2012); Lan et al. (2012); Ryu and Parsons (2012); Sanchez and Olivares (2011); van der Meij, Albers, and Leemkuil (2011); Vos et al. (2011); Yang (2012b)</td>
</tr>
<tr>
<td>Role Playing</td>
<td>7</td>
<td>Dzeng et al. (2014); Hamalainen and Oksanen (2012); Howland and Good (2015); Robertson (2012); Vos et al. (2011); van der Spek and van Oostendorp (2013); Yang and Chang (2013)</td>
</tr>
<tr>
<td>Exploration</td>
<td>6</td>
<td>Ahmed and Parsons (2013); Chiang et al. (2014); Ke (2014); Lazonder et al. (2010); Ryu and Parsons (2012); Yang (2012b)</td>
</tr>
<tr>
<td>Narrative</td>
<td>6</td>
<td>Howland and Good (2015); Hou and Li (2014); Ke (2014); Lester et al. (2014); Robertson (2012); Yang and Chang (2013)</td>
</tr>
<tr>
<td>Complexity</td>
<td>5</td>
<td>Akcaoglu and Koehler (2014); Lester et al. (2014); Pasin and Giroux (2011); Ranchhod et al. (2014); Yang and Chang (2013)</td>
</tr>
<tr>
<td>Competition</td>
<td>4</td>
<td>Johnson and Mayer (2010); Ranchhod et al. (2014); Vos et al. (2011); Yang (2012b)</td>
</tr>
<tr>
<td>Strategy</td>
<td>4</td>
<td>Barzilai and Blau (2014); Hamlen (2012); Liu et al. (2011); van der Meij et al. (2011)</td>
</tr>
<tr>
<td>Challenge</td>
<td>3</td>
<td>Hou and Li (2014); Johnson and Mayer (2010); Liu et al. (2011)</td>
</tr>
<tr>
<td>Clear goals</td>
<td>3</td>
<td>Hou and Li (2014); Johnson and Mayer (2010); Ryu and Parsons (2012)</td>
</tr>
<tr>
<td>Communication</td>
<td>3</td>
<td>Ahmed and Parsons (2013); Charitonos et al. (2012); Lan et al. (2012)</td>
</tr>
<tr>
<td>Discovery</td>
<td>3</td>
<td>Chiang et al. (2014); Lazonder et al. (2010); Yang (2012b)</td>
</tr>
<tr>
<td>Immediate feedback</td>
<td>3</td>
<td>Chang, Wu, Weng, and Sung (2012); Dzeng et al. (2014); Pasin and Giroux (2011)</td>
</tr>
<tr>
<td>Augmented reality</td>
<td>2</td>
<td>Chang et al. (2011); Chiang et al. (2014)</td>
</tr>
<tr>
<td>Control</td>
<td>2</td>
<td>Yang and Chang (2013); Yang and Wu (2012a)</td>
</tr>
<tr>
<td>Interactivity</td>
<td>2</td>
<td>Lester et al. (2014); Vos et al. (2011)</td>
</tr>
<tr>
<td>Low stakes failure</td>
<td>2</td>
<td>Liu et al. (2011); Yang (2012b)</td>
</tr>
<tr>
<td>Realism</td>
<td>2</td>
<td>Pasin and Giroux (2011); Ranchhod et al. (2014)</td>
</tr>
<tr>
<td>Rules</td>
<td>2</td>
<td>Hou and Li (2014); Johnson and Mayer (2010)</td>
</tr>
<tr>
<td>Scaffolds</td>
<td>2</td>
<td>Barzilai and Blau (2014); Liu et al. (2011)</td>
</tr>
<tr>
<td>Self-expression</td>
<td>2</td>
<td>Akcaoglu and Koehler (2014); Yang and Wu (2012a)</td>
</tr>
<tr>
<td>Curiosity</td>
<td>1</td>
<td>Yen and Lee (2011)</td>
</tr>
<tr>
<td>Explanation</td>
<td>1</td>
<td>Ryu and Parsons (2012)</td>
</tr>
<tr>
<td>Immersion</td>
<td>1</td>
<td>Sanchez and Olivares (2011)</td>
</tr>
<tr>
<td>Rewards</td>
<td>1</td>
<td>Chang et al. (2012)</td>
</tr>
<tr>
<td>Scripted game play</td>
<td>1</td>
<td>Hamalainen and Oksanen (2012)</td>
</tr>
<tr>
<td>Social</td>
<td>1</td>
<td>Charitonos et al. (2012)</td>
</tr>
<tr>
<td>Surprise</td>
<td>1</td>
<td>van der Spek and van Oostendorp (2013)</td>
</tr>
<tr>
<td>Uncertainty</td>
<td>1</td>
<td>van der Spek and van Oostendorp (2013)</td>
</tr>
</tbody>
</table>
significantly improved students’ critical thinking skills (partial $\eta^2 = 0.10$), significantly increased their achievement (partial $\eta^2 = 0.07$), and revealed a significant retention of critical thinking skills one month later (partial $\eta^2 = 0.18$) (Yang & Chang, 2013).

Lazonder et al. (2010) designed an educational game based on Scientific Discovery as Duel Search Model (SDDSM). Game design elements were exploration and discovery. Students generated more specific hypotheses when they were given access to domain information via help files (Cohen’s $d = 1.87$ to 2.23). However, participants who had access to domain information performed less exploratory experiments than the group with no access to domain information (Cohen’s $d = 2.79$) (Lazonder et al., 2010).

5. Discussion

The current review focused on positive impacts of game-based learning on the development of 21st century skills. Our initial search returned 3118 peer-reviewed journal articles, and Fig. 1 suggests that there is an increasing interest in digital media and games for learning.

In the end, 137 papers met our inclusion criteria and were selected for this review. These studies were diverse in terms of learning outcomes, game genres and participants’ ages, reflecting the wide range of interests in games for learning. But as expected, the most frequently occurring outcomes were still behaviors and attitudes (42%) as well as cognitive gains (38%). The most frequently used game genre was educational (e.g. serious games, simulations, educational, edutainment) (50%), and a relatively small proportion of the studies employed entertainment games (25%) or mobile games (15%), although the latter remains very popular as daily entertaining activities. In other words, whereas entertainment games are known for its exciting and engaging features (e.g., adaptive challenge, player control, and variable rewards) and have potential to promote meaningful learning (e.g., Anderson, 2011; Gee, 2007; Squire, 2011), its actual capability of serving as a powerful learning tool still needs further investigation.
29 studies targeted 21st century skills as outcomes, with 13 reporting effect sizes. Specifically, while creativity, critical thinking, collaboration and communication play equally important roles in students’ development, critical thinking skills turned out to be the most frequently investigated outcome. Even more surprisingly, only one of the 29 studies reported results about communication, and a few investigated creativity, although creativity, as part of 21st century learning models, has been emphasized in curricular frameworks around the world (e.g., Ananiadou & Claro, 2009; Chan & Yuen, 2014; Pellegrino & Hilton, 2013; Trilling & Fadel, 2009). Hence, studies in the future need to explore how games, especially educational games might foster students’ 21st century skill development in terms of communication and creativity.

With regard to the age group, a similar pattern was observed. Less than one third (27%) of the 29 studies focused on higher education, and the majority (60%) were devoted to elementary, middle and high school students. This is an exciting finding because young kids and teenagers constitute the major force whose 21st century skill development will be heavily impacted by technology.

A further review of the 29 articles investigating 21st century outcomes indicates that 22 referenced one or more learning theories as a theoretical framework. The most commonly referenced theoretical foundations were constructivism and constructivism (see Table 1). Both merge nicely with naturalistic game play as learning takes place when it is social, active, and situated (e.g., Vygotsky, 1978). Also, according to Wu et al. (2012b), GBL is more likely to yield positive outcomes when learning theories are incorporated into the design. Fortunately, the present study shows that most of the 29 articles targeting 21st century skills as learning outcomes did focus on existing learning theories. The challenge for instructional designers is the complex task of designing a game with the goal of intentional instruction (Becker, 2007) without alienating the player by inserting overt academic content or stressing learning outcomes that do not blend seamlessly with the game mechanics. In other words, maintaining the state of flow is important, but flow theory was only explicitly referenced in two of these studies (i.e., Hou & Li, 2014; Ryu & Parsons, 2012).

As far as game design elements are concerned, games that present materials in a quiz format or drill and practice format do not engage learners (e.g., Lester et al., 2014; Ruggiero & Watson, 2014; Squire, 2003), while well-designed games can engage learners in reflective thinking (Johnson & Mayer, 2010). The majority of the 29 papers investigating GBL impacts on 21st century skills employed multiple game-design elements, with collaboration, role playing, narrative, exploration, and complexity being the most popular ones (see Table 2). Therefore, these GBL studies focused on complex game designs rather than the typical educational drill and practice or simple quiz design.

Collaboration was the most frequently targeted game design element in the 29 papers reporting 21st century skills outcomes (see Table 2). Collaboration and competition are game-design elements used to engage players in social interactions that lead to persistence in game play. Well-designed games such as massively multiplayer online role-playing games (MMORPGs) pose various challenges that encourage collaborative problem solving (Steinkuehler, 2008); thereby giving individuals opportunities to develop 21st century skills.

Role playing was the second most frequently targeted game design element in these papers (see Table 2). Role playing in virtual worlds can give the player a sense of identity within the game and effectively enhance students’ real-world competency. Twining (2010) suggests that virtual worlds offer role playing experiences that engage learners in activities that can be as real as anything experienced in a physical classroom.

Entertainment games capitalize on design elements such as adaptive challenge, curiosity, self-expression, discovery, clear goals, player control, immersion, collaboration, competition, immediate feedback, variable rewards, and low-stakes to maintain learners’ motivation and keep them actively involved throughout the game (e.g., Anderson, 2011; Gee, 2007; Squire, 2011). Educational games can use all of these design elements to engage students and provide opportunities to develop valued 21st century skills as well (Anderson, 2011; Csikszentmihalyi, 1990; Gee, 2007; Shute, 2011; Squire, 2011).

Another major finding of the present study is that 29 articles investigating 21st century skills reported 97 outcomes in total. While the majority of the results (85%) were statistically significant, the practical significance of nearly half of the empirical findings (48%) remains unknown (see Fig. 3). In other words, those studies have limited practical implications as effect sizes were not reported.

Table 3 further suggests that studies which reported medium to large effect sizes employed either educational games, entertainment games, or design-based games. Design-based games seemed to be more effective than educational or entertainment games as 17 out of 28 results were practically significant (see Table 3). In addition, six papers (21%) used mobile augmented reality or mobile games. But no effect sizes were reported. Hence, it is hard to evaluate whether mobile games are truly effective or not, although it is getting increasingly popular among students due to the prevalence of electronic devices such as smart phones, tablets and iPads (e.g., Squire & Dikkers, 2011).

Table 4 shows that a number of game design elements were implemented in those GBL studies that reported moderate to large effect sizes. They are collaboration, competition, complexity, exploration and discovery, role play, self-expression and interactivity. Therefore, it is recommended that researchers and practitioners who aim to promote students’ 21st century skill development using GBL emphasize these game design elements when selecting or creating effective educational games in the future.

5.1. Limitations

The current review has several limitations. First, quantitative studies instead of qualitative research on the effectiveness of GBL were selected as we aimed to analyze both statistical and practical significance of empirical findings. Second, the review focused on studies that were published in six journals in 2010—2014. Based on the rapid pace of technology advancement and change, a five year time frame captures recent and advanced technologies and usages. The papers discussed in this literature review provide researchers and practitioners with great insights concerning the impacts of GBL on the development of 21st century skills. However, an extended review which includes articles published in all the technology-related journals might be able to provide additional information.

5.2. Conclusion

The current review analyzed the impacts of GBL on 21st century skills development in depth and revealed that the effectiveness of GBL seems to depend on game designs. Specifically, game designs which feature a blending of established learning theories with game design elements proven successful in the entertainment game industry are most likely to lead to effective learning. With regard to game genres, design-based games tend to work better than simply having students play educational or entertainment games. In summary, the present study indicates there is reason to be optimistic about the potential of using a game-based learning approach to promote 21st century skill development in the future,
although only one third of the empirical findings were associated with medium to large effect sizes and a few studies targeted creativity, communication and collaboration as learning outcomes.

References


