

## Critical Thinking, 21st Century, and Creativity Skills

### *Teaching 21st Century, Executive-Functioning, and Creativity Skills with Popular Video Games and Apps*

**Randy Kulman**, *LearningWorks for Kids, PeaceDale, Rhode Island, U.S.*,  
[randy@learningworksforkids.com](mailto:randy@learningworksforkids.com)

**Teresa Slobuski**, *Dr. Martin Luther King, Jr. Library, San Jose State University, San Jose, California, U.S.*,  
[Teresa.Slobuski@sjsu.edu](mailto:Teresa.Slobuski@sjsu.edu)

**Roy Seitsinger**, *Westerly Public Schools, Westerly, Rhode Island, U.S.*,  
[rseitsinger@westerly.k12.ri.us](mailto:rseitsinger@westerly.k12.ri.us)

#### Key Summary Points

1

21st century skills, including flexible thinking, collaborative communication skills, executive function and critical thinking skills, and digital literacy, will be necessary for education and jobs in the future.

2

Video games and apps are an extremely powerful tool for teaching 21st century skills due to game mechanics that build in learning principles and their highly engaging nature.

3

Games such as *Minecraft*, *Portal 2*, and a variety of casual video games have been demonstrated to teach skills, such as problem solving, processing efficiency, cognitive flexibility, and the 21st century skill of digital literacy.

#### Key Terms

21st century skills

Executive functioning

Creativity skills

Digital literacy

Common core state standards

Long-form games

Short-form games

## Introduction

The skills needed for success in the future will go far beyond the content conventionally taught in U.S. schools. Success, today, and tomorrow, will require 21st century skills such as creativity, collaboration, executive functioning, and digital literacy (Trilling & Fadel, 2009). No longer will simple rote learning, memorization of facts, or training for traditional manufacturing, service, or agricultural jobs be adequate to prepare students for life and work in the future (*21st Century Skills and the Workplace, Microsoft, Pearson Report 2013*). Instead, 21st century skills defined by the capacity to think flexibly and innovatively (creativity); the aptitude to communicate with colleagues both face to face and digitally (collaboration); capability in planning, self-management, organization, time management, and critical thinking (executive functions); and the knowledge of how to use electronic media and tools (digital literacy) will become the core proficiencies for future success. The use of video games and apps has potential for encouraging the practice of creativity, collaboration, executive functions, and digital literacy.

Employers around the globe are looking for 21st century skills in their new hires to help them adjust to information-focused jobs that require problem solving, teamwork, the capacity to identify relevant facts, and organizational, planning, and efficiency skills. In 1990 the U.S. Department of Labor's Secretary's Commission on Achieving Necessary Skills report indicated that a variety of functional skills are needed to be successful at the modern workplace such as, resource management, social interaction, human and technology interaction, and affective skills (Kane, Berryman, Goslin & Meltzer, 1990). Educators, meanwhile, are rethinking how best to prepare children to meet these workforce needs by incorporating digital technologies and collaboration in the classroom.

In the U.S., the latest national education standards, the Common Core State Standards (CCSS) (National Governors Association Center for Best Practices (NGA Center) & Council of Chief State School Officers (CCSSO), 2010), attempt to meet these market demands by encouraging many of these skills along with more traditional academic content. Although concepts such as "teaching the whole child" and going beyond the fundamentals are not new in educational research, CCSS's national predecessor policy, No Child Left Behind (NCLB) (U.S. Department of Education, 2013), limited these educational aims through mandatory testing, which requires teachers to focus on content alone. For many educators, NCLB is seen as a stumbling block to teaching 21st century skills (Schoen & Fusarelli, 2008; Noddings, 2005). CCSS, however, integrates many 21st century skills through its standards on college and career readiness such as creativity, collaboration, and digital-technology use. Thus, as CCSS becomes integrated into classroom curricula, teachers have an opportunity to expand their teaching of these skills and many are finding that video games are one method to supplement the teaching of these skills.

In this chapter, we will consider 21st century skills as imperative to success during and after school. Rather than competing with the curriculum, 21st century skills can and should be integrated into the student experience. One of the more powerful ways of building 21st century skills is through the use of digital games and technologies, whether the content focus is on 21st century skills or not.

## Key Frameworks

### What are 21st century skills?

21st century skills are defined by the Partnership for 21st Century Skills (2009) as having three components:

1. **Learning and innovation skills**, which include creative thinking and problem solving and communication and collaboration. These skills are crucial to working in a group, developing new ideas, and analyzing and evaluating information.
2. **Life and career skills**, which encompass skills such as flexibility and adaptability; initiative and self-directed social and cross-cultural skills; productivity and accountability skills; and leadership and responsibility skills, many of which can also be described by the term executive functions. Executive functions are defined as brain-based cognitive skills that support self-management and critical thinking. Executive functions are based primarily in the prefrontal cortex of our brains and orchestrate various brain functions that integrate a person's perceptions, experiences, cognitions, and memories toward goal-directed behavior. These are identified by many experts as the key to academic and vocational success in the 21st century (Brown, 2013; Barkley, 2012). Executive functions include a set of related skills that help prioritize, regulate, and orchestrate an individual's thoughts and behaviors.
3. **Digital literacy skills**, which include understanding about digital information; being able to access information effectively; evaluating, analyzing, and using media; and being able to apply technology effectively. Proficiencies in being able to create media use technology for research, and competencies in using a variety of electronic forms of communication and networking tools are core digital literacy skills (Partnership for 21st Century Skills, 2009).

### What are the Common Core State Standards?

The Common Core State Standards (CCSS) define the educational content and expectations of performance of students at all levels. The CCSS were developed with the recognition of the global nature of competition for jobs and the expectation of what workers need to know and be able to do. To prepare students for an increasingly competitive workforce, the CCSS are “staircased” in increasing complexity to guide students toward full readiness for college and career. To date 45 states, the District of Columbia, 4 territories, and the Department of Defense schools have adopted the CCSS based on these observations.

In drafting the CCSS, the Council of Chief State School Officers (CCSSO) and the National Governors Association Center for Best Practices (NGA Center) worked with a variety of stakeholders to develop standards that reflect the skills and experience necessary for American children to succeed in college and their careers. Not only does the CCSS cover what content is necessary for students to succeed, but it also recognizes the importance of a variety of 21st century skills throughout the standards. For example, the introduction to the CCSS for “English Language Arts & Literacy in History/Social

Studies, Science, and Technical Subjects” states that students who are college- and career-ready are able to “demonstrate independence,” “respond to the varying demands of audience, task, purpose and discipline,” “use technology and digital media strategically and capably,” and “come to understand other perspectives and cultures” (NGA Center & CCSSO, 2010, p. 7), each of which is intimately tied to one or more 21st century skills. Throughout the standards there is additional emphasis on building students’ ability with “flexible communication and collaboration,” (NGA Center & CCSSO, 2010, p. 8) a large piece of the 21st century skill puzzle. By using video games to teach skills such as collaboration and creativity teachers are able to provide students an opportunity not only to develop those skills, but also to increase their digital literacy skills.

### **Selecting Case Studies**

Games are a particularly powerful tool for teaching 21st century skills because their reach extends beyond the classroom. Children ages eight to 18 spend an average of seven hours and 38 minutes per day using digital media (Rideout, Foehr, & Roberts, 2010), strongly suggesting that they are more than willing to play games and apps on their own as a part of homework or to pursue their own interests. Teachers are increasingly turning to a variety of types of games for their teaching. One of the common observations described by teachers who use games in the classroom is the level and sophistication of engaged discussion that takes place among classmates that leads to additional learning and insights (Cornally, 2012).

Selecting video games that can target specific skills and engender the type of engagement that encourages learning that goes beyond the classroom is one of the keys to game-based learning of 21st century skills. Both long- and short-form games can be implemented in the classroom to aid in teaching 21st century skills. Long-form games, which are more open-ended and may take place over many hours at home and school, can be used as a teaching tool. Examination of two long-form games, *Minecraft* and *Portal 2*, demonstrates how these types of games are being implemented in classrooms. Short-form games can be played within a single class period, and multiple games can be combined in a suite.

## Case Study One: *Minecraft*

*Minecraft* is one of the most recognized and widely played games in the United States and counts 45 million people as having registered for the games (MinecraftEdu.com, n.d.). *Minecraft* is becoming a widely used game in many classrooms around the world due to the flexibility, ease of entry of the game, and mass appeal. *Minecraft* is an open-world game without specific goal. It has two major modes: survival, which requires players to acquire resources, maintain their health, and survive the night, and creative, which focuses on designing, constructing, and creating large projects. In addition to the standard version of *Minecraft* available through the developer, teachers have modified the game for better applicability in the classroom. Minecraftedu.com, developed by Joel Levin, a computer teacher, provides teachers with access to a customized *Minecraft* modification designed specifically for classroom use and has been used by more than 250,000 students to date (MinecraftEdu.com, n.d.).

While *Minecraft* does not contain specific curricula designed to teach 21st century skills, many of the classroom-based *Minecraft* projects are described as practicing executive-functioning, creativity, and collaboration skills (Levin, 2013). Rather than seeing *Minecraft* as being used for its 21st century skill building alone, Levin notes that many of the examples of *Minecraft* used in the classroom start off by being content driven and cover diverse topics such as Roman history, Newtonian physics, or mathematics. He described how the lesson plans generally start by focusing on a more traditional classroom objective such as understanding gravity, but that through playing *Minecraft* students frequently use a variety of 21st century skills such as innovation, creativity, and cognitive flexibility. Levin (2013) describes how student assignments often involve the division of tasks and time-management and collaboration skills. Learning how to access knowledge outside of the game to answer questions involves digital literacy skills. The skill of creativity is another necessary and important component of the world construction that takes place in *Minecraft*.

The use of *Minecraft* as an afterschool program is being planned at the Central Falls School District in Rhode Island by Michael St. Jean, the assistant superintendent of Central Falls Schools. St. Jean, who has written extensively about the powerful nature of *Minecraft* from his perspective as an educator and as the parent of a 13-year old-son who has embraced the game, describes *Minecraft's* utility for teaching 21st century and problem-solving skills. He describes how the employment of *Minecraft* in the classroom is useful in teaching 21st century skills and the common core curriculum. He suggests that because the common core curriculum is based in part on project-based learning, *Minecraft* is an excellent opportunity for creativity, making and fixing mistakes, and conceptual understanding of materials. St. Jean also suggests that the computer skills necessary for becoming an expert at *Minecraft*, such as coding and modding, powerfully reinforce the digital literacy component of 21st century skills (St. Jean, 2013).

St. Jean further describes how *Minecraft* can be a great tool for teaching life and executive-functioning skills. He recounts that his son has announced that he wants being engineer or an architect and now notices the designs of buildings and is fascinated with books on historical architecture as a direct result

of playing *Minecraft*. After seeing a similar potential after using *Minecraft* in a national competition on how to make a better future, a school in Sweden has added playing *Minecraft* as part of their compulsory curriculum. One teacher from the school stated that the students use *Minecraft* to “learn about city planning, environmental issues, getting things done, and even how to plan for the future” (Gee, 2013). Through the process of building *Minecraft* structures, students can learn skills and develop interests that will be important in meeting the needs of our collective future.

## Key Findings

### Video games, technology, and 21st century skills

Playing and using video games and technology can be strongly related to the development of 21st century skills. Gee (2007) identifies 36 “learning principles” that are built into good video games that can be leveraged as effective teaching tools. Many of Gee’s learning principles, such as the active, critical learning principle; the multiple routes principle, and the probing principle parallel 21st century skills. Other studies describe how video games are excellent tools for teaching problem solving (Shaffer, 2006), strategic thinking (Adachi & Willoughby, 2013), cognitive flexibility (Green et al., 2012), and executive functions (Kulman et al., 2011). A comprehensive review of game-based learning found that video games could impact positively on problem-solving skills, motivation, and engagement, all of which support using these digital tools in teaching 21st century skills (NFER, 2013).

The use and mastery of technology as crucial for 21st century skills becomes evident as educators begin to define the components of these skills. Far more than simple digital literacy, engagement with video games, apps, and interactive digital media requires collaboration, critical thinking, adaptability, creativity, and decision-making skills. While primarily citing the use of the Internet and productivity tools, many educators now make the argument that video games can also be readily adapted for the teaching, development, and improvement of 21st century skills.

As 21st century skills are more deeply explored, many connections can be seen between the use of video games and digital technologies and the development of these important capacities. For example, many video games and digital technologies require learning and innovation skills such as critical thinking and problem solving, communicating and collaboration, and creativity and innovation for the user to be successful. Additionally, they do so in a manner in which high levels of motivation and sustained attention and effort are devoted to developing these skills. By capturing the attention of the users, these games are able to teach many of these skills through successful gameplay.

Many games require an array of problem solving, thinking, and planning skills such as *The Legend of Zelda* or the *Civilization* series. In *Legend of Zelda: Twilight Princess*, an action adventure game, players must learn to use planning skills when they buy items at shops and stock up on bombs and arrows to survive difficult dungeons to come. *Civilization*, a series of turn-based strategy games, requires players

to choose where to place their energy in building new structures, improving existing ones, moving units, initiating negotiations, etc. to advance their civilizations' growth. Games such as *Legend of Zelda* and *Civilization* make players into critical thinkers by encouraging successful gamers to think many steps ahead.

Video games are increasingly integrating communication and collaboration as key components of play. Communication can be key to survival and a requirement for maximum success in massive multiplayer online role playing games (MMORPGs). In *World of Warcraft*, thousands of players stage raids to defeat particularly difficult dungeon challenges, which can include as many as 40 individuals working to defeat the same boss. Without advanced communication skills, collaborations of that size would not be possible in or out of the game world.

Creativity and innovation can frequently be seen in open video game platforms such as Scratch, a suite of interactive media creation tools from MIT or *Crayon Physics*, a puzzle game that requires users to create drawings that have realistic physics applied to solve the level. In addition to using creativity and innovation in gameplay, many gamers further practice using these skills in a variety of activities inspired by their play. Some gamers may continue to engage with a game by creating a website, contributing to a wiki, or participating in forums. Some games, particularly PC games, allow users to augment the game through a process known as modding. By writing their own parts of computer programs, gamers can develop custom maps, create a different interface, or visualize information otherwise unavailable to augment their gaming experience (Kow & Nardi, 2009; Brown, 2008). Modding allows gamers to be creative by altering a game as they see fit.

Life and career skills require the capacities for self-management, goal setting, decision-making, and adaptability. Although these skills are not often formally taught in the classroom, they remain important markers for success both in academics and in the workforce. By providing situational practice of these skills, many video games can benefit players outside of the game world.

By their very nature, video games and digital technologies require flexible thinking as problem-solving strategies change from one level to another. For example, in *Angry Birds*, structures are made from a variety of materials such as wood and metal, with unique layouts requiring the player to dramatically change strategies. An inflexible mind may attempt to break through metal as one can with wood structures, but will ultimately be unsuccessful in completing the level. Recognizing the differences between various situations and adapting play techniques accordingly is key to winning in *Angry Birds* and mirrors the flexibility required for adapting to real life situations.

Working independently and setting goals to maximize productivity are important parts of many complex video games. In the *Metal Gear Solid*, an action adventure stealth game, players normally move through the game attempting to attract minimal attention while completing their quests. The player, however, can determine what that means in a given situation, whether it means sneaking past to avoid being seen or killing guards as quickly as possible. Newer releases of the series have recognized

the fun and challenging nature of “self rule” in the games and now provide additional achievements for different types of play, for example completing the game without killing enemies by choosing to tranquilize or avoid them instead.

Leadership and responsibility skills are noteworthy in many MMO games. These games often include guild or party structures where players work together to better everyone’s play experience. To manage resources and be successful in play with larger groups, one or more players must take on a leadership role. Additionally, by agreeing to play in a party or be part of a guild, players agree to be responsible for holding their weight for the team. This may be in the form of collecting resources to prepare for a large battle or keeping an eye on other players during battle. Reeves (2008) conducted a study in which it was found that playing *World of Warcraft* was very useful for developing leadership skills such as visioning, sense-making, relating, and inventing that are crucial to business. Given the number of elements an advanced *World of Warcraft* player needs to balance, it is unsurprising to see those skills transfer into the real world.

Digital literacy skills are core requirements for expertise with video games and use of other digital media. As video gamers are digital in nature, any time spent playing can help increase a gamer’s digital literacy skills and comfort with digital technologies. Gaming can additionally inspire players to interact with various digital technologies to support, augment, or share their gaming experience.

In many families, the expert at learning how to use a new cell phone, connect the cable box, or get the Internet back online is the video gamer. A multi-system gamer can be equally comfortable using a computer, console, or mobile device for their gameplay. Besides using the devices for actual play, a gamer may be responsible for setting up the hardware and/or software of the systems to start playing. Although knowing how to properly connect a new computer may not seem like an impressive feat, as digital technologies continue to be more integrated into our everyday experience, comfort with setting up and troubleshooting new technologies is an essential part to basic digital literacy.

Outside of active gameplay, many avid gamers are continuing to develop their digital literacy skills in affinity groups. Affinity groups are defined by Gee (2004) as places of informal learning where “newbies and masters and everyone else” (p. 85) all interact around their common interest, which could be a video game, television show, novel, etc. These affinity groups allow fans from diverse backgrounds to come together and discuss, learn, and share about their interest. Communities like this can not only feed into the social skills of an individual, but also help to increase ease of digital technology use. Learning to leverage the learning experiences occurring in these affinity groups will be key to harnessing the full educational potential of video games (Steinkuehler, 2004).

Earlier in Internet history, gamer interaction may have been limited to searches for cheat codes or walkthroughs to assist in completing difficult or tedious elements of gameplay. Today, increasing numbers of gamers are creating original content to share with the world including wiki editing, forum participation, and making “let’s play” videos to demonstrate how they play their favorite video games.



This original content can then be used by fellow gamers and may inspire them to create their own original content. By participating in an ever-growing digital culture of gaming, gamers not only learn how to use technology to play games, but also learn how to use it to communicate with others, express themselves, and otherwise navigate the digital landscape.

Innovation, life and career, and digital literacy skills are vitally important for future jobs and must be incorporated into education in the 21st century. There is a wealth of research (Galinsky, 2010; Goldberg, 2001) showing that mastering 21st century skills, defined more broadly with terms such as “executive-functioning skills” (Diamond, 2007) and “learning skills” (McClelland, 2007), can be more important for academic learning than direct teaching of the same academic subjects. Many studies indicate that learning critical-thinking skills and creativity at a young age results in greater future academic achievement than if those same students were taught with a traditional curriculum (Willoughby et al., 2012; Diamond, 2012). The research shows that some of the time and energy devoted to instructing students in math and language skills would be better spent in teaching 21st century executive functioning, critical thinking, and creativity skills. Additionally, teaching academic and problem solving skills through the use of video games and other digital media has been repeatedly demonstrated (Clarfield & Stoner, 2005; Ota & DuPaul, 2002) to be a more powerful and engaging learning tool than what is used in the traditional classroom.

## **Case Study Two: *Portal 2***

Another commercial video game gaining adoption in classrooms for a variety of uses is Valve Corporation’s *Portal 2*. Unlike *Minecraft*, normal play in *Portal 2* has clearly-defined goals for the players. Throughout the game, players are presented with rooms that require players to solve the puzzle to move forward. These puzzles generally involve use of the portal gun, a gun-like apparatus that creates portals between various wall/floor/ceiling surfaces, as well as other items in the environment, and require cunning and creativity to be successful. The game has garnered attention from educators not only for the innovative gameplay, but also for the robust puzzle maker, which furthers the possibilities for educational use by allowing individuals to design custom levels. Additional support for educators interested in using *Portal 2* can be found through the *Steam for Schools Teach with Portals* program (*Teach with Portals*, 2013).

As essentially a puzzle game, *Portal 2* requires players to meet each puzzle with sharp critical thinking skills, creativity, and cognitive flexibility. As players move through campaign gameplay, an increasing number of elements become necessary for puzzle solving, such as propulsion gel, turret attackers, and a thermal discouragement beam. Players must use the knowledge they have gained from previous puzzles as these elements are reused throughout the levels while remaining flexible enough to recognize new opportunities. In addition to single-player mode, *Portal 2* also features a cooperative-campaign mode in which two players must coordinate their actions and resources to successfully complete more

complicated puzzles than they experienced in a single player. Throughout both the campaign modes players continuously practice many 21st century skills while enjoying the immersive environment of *Portal 2*.

The Perpetual Testing Initiative, a post-release DLC (downloadable content) for *Portal 2*, has further expanded the educational potential of *Portal 2*. The DLC includes a puzzle maker, which allows gamers to build their own puzzles using all of the *Portal 2* elements. *Portal 2*'s level editor has provided an opportunity for deeper levels of learning using *Portal 2*'s framework by allowing teachers and students to develop levels and challenges using the *Portal* framework. Many of the puzzles built for educational purposes have a content-specific focus, such as teaching a lesson about physics. The nature of the game, however, will always require players to think critically and creatively to solve the puzzle. In addition to creating levels for one's own enjoyment, the Perpetual Testing Initiative allows players to share their creations with others, which allows the spread of educational uses of *Portal 2*.

Due to the ease of entry into puzzle making with *Portal 2*'s Perpetual Testing Initiative, teachers quickly appropriated the game for educational use. Recognizing the educational potential, the Valve Corporation created an educational game distribution unit, Steam for Schools, and began promoting the educational use of *Portal 2* through *Teach with Portals*. On the *Teach with Portals* website, instructors can see example lesson plans and communicate with other educators through the forum and wiki. The website provides *Portal 2*-using instructors with a space of their own where they can form an affinity group to discuss and share how they teach with *Portal 2*. Additionally, *Steam for Schools* provides free and cheap game access for teachers to use in their class (*Teach with Portals*, 2013), which helps lower one of the largest barriers to using commercial games.

## **Assessment Considerations**

Given the impending changes to educational needs, how to properly assess 21st century skills are at the forefront of many educators' minds. As these are skills of practice rather than content knowledge, they can be difficult to quantify or measure reliably. Given the time required to accurately administer and grade assessments of these skills, mass adoption of any one assessment is unlikely due to problems in scaling. In the future, video games could be used as a means to assess 21st century skills. By requiring use of these skills to successfully complete a particular level or challenge, the game may serve as both the teacher and assessor of these skills. Currently, *River City*, an educational game designed for middle school science, is a working example of simultaneous teaching and assessing (Silva, 2009). The best methods of reporting to integrate into varied classroom experiences, however, are still relatively early in development.

While educators wait for technology to catch up, a variety of standardized tests already exist that can be used to measure students' 21st century skills. Several tests attempt to measure more than one of the 21st century skills defined earlier in this chapter. For example, the College Work Readiness Assessment

(CWRA) is a 90-minute exam intended to test how students manage a real-world dilemma, however it is not focused on individual student achievements, but is a tool for class or school improvement (Silva, 2009). The International Society for Technology in Education (ISTE) has developed a series of standards for students that include all of the previously discussed 21st century skills (ISTE, 2012). Although primarily for an undergraduate student audience, the Association of American Colleges and Universities (AAC&U) VALUE rubrics can be useful for examining a variety of skills. Rubrics that cover 21st century skills from AAC&U include: creative thinking, oral communication, written communication, critical thinking, and problem solving (AAC&U, 2014). The iSkills test combines critical thinking with technology by requiring test takers to perform scenario-based tasks using information provided in a digital format (Educational Testing Service, 2014).

This chapter cannot provide a comprehensive listing, but a variety of tests or rubrics are widely available that attempt to measure specific elements within the umbrella of 21st century skills, including (in no particular order): Torrance Tests of Creative Thinking (TTCT) (Scholastic Testing Service, 2013), California Critical Thinking Skills Test (CCTST) (Insight Assessment, 2013), Cornell Critical Thinking Tests (Critical Thinking Co., 2014), and Watson-Glaser Critical Thinking Test (Pearson Education, 2012).

Given the difficulty and cost of assessing many 21st century skills on a large scale, institutions or individual teachers may choose to develop their own criteria for measuring these skills. Creating rubrics for project assessment that include measurement of 21st century skills is one method to help students recognize the importance of 21st century skills in their success and allow teachers to understand where their students are on work/life skills. Checklists, learning contracts, or student reflections are additional methods for teachers to assess 21st century skills and emphasize the importance of their development in these areas to students. Each of these methods are quite time consuming, however, and with increasingly poor teacher to student ratios in many of our school systems, the feasibility for complete assessment of these skills in the majority of classrooms is minimal (Greenstein, 2012).

## **Future Plans**

Research into the impact of game-based learning and behavior modification is in its infancy, and its potential is only just now being realized. Both long-form and short-form games can have their place in the classroom, but questions remain regarding how to maximize their usefulness. Researchers will need to answer questions such as, “How long should children play games?” “How can they best be integrated into a classroom curriculum?” “Are there limits to what can be transferred via game-based learning?” and more before the mass adoption of games can occur in K-12 classrooms. Furthermore, researchers need to further investigate the measurement of 21st century skills, especially as they relate to gameplay, to maximize efficiency in this arena.

Whether at school or at work individuals need to have the necessary 21st century skills to contribute and succeed. Creating new classroom strategies that support growth in creativity, collaboration, executive functioning, and digital literacy is the charge of parents, educators, and specialized student support staff.

Digital tools and gaming will be a prominent feature as schools reshape the methods and means of classroom instruction and use standards-based reforms to articulate curriculum and instruction in the 21st century. The ubiquitous nature of cloud-based smart tools allows schools to set aside the physical limitations of place, time, textbooks, and learning labs in favor of anywhere/anytime learning strategies, which creates opportunities for game-based learning as homework, during the bus ride to school, and as collaborative efforts from the comfort of a student's home. These types of strategies will enhance the acquisition of content and the growth of critical thinking skills, ultimately increasing the capacity of individuals and entire systems in the name of effective learning experiences. The myriad technological and content-specific curricula that embed gaming opportunities allow learning through gaming to become a permanent, possibly even dominant, component of building skills and knowledge.

### **Case Study Three: Short-Form Games**

Given the demands of achieving the common core standards in the classroom, it can be difficult to have the dozens, if not hundreds of hours needed to use a game such as *Minecraft* or *Portal 2* to teach 21st century and executive function skills in a 50-minute class period. Fortunately, many short-form or casual games can be powerful tools for the practice and acquisition of these skills. Short-form games can have the advantage of being more targeted toward the development of a particular skill (Squire, 2008) and for being useful over the course of one-to-two classroom sessions. The Cooney Foundation strongly encourages schools to consider the use of short-form games for classroom teaching, as “collections of short-form games can be particularly attractive to schools because they have the ability to fit well into the current K-12 classroom structure and are easier to align to standards” (Richards et al., 2013).

Emerging research (Kulman et al., 2011; Klingberg, 2010; Baniqued et al., 2013) suggests that the targeted use of short-form games such as *Bloxorz*, *Silversphere*, and *Blobber* can improve skills such as problem solving, processing efficiency, working memory, and cognitive flexibility. While there are limited classroom studies, pilot research (Kulman et al., 2012) suggests a number of strategies for using casual, short-form games for classroom teaching of 21st century and executive skills. These strategies include:

1. Engaging in warm-up activities that practice and discuss the importance of the skill to be used in the game;
2. Demonstrating identification and reflection upon the skill through modeling the first part of the game for the class;
3. Encouraging teamwork and collaboration to overcome frustration of getting stuck on challenging levels;
4. Setting specific and achievable goals for gameplay rather than simply playing for a specified amount of time; and
5. Supporting engaging, high-level connection and generalization activities at the conclusion of gameplay.

There are many advantages to using short-form games for teaching 21st century skills in the classroom. Because they are shorter, more defined, and less immersive, students will have the time and inclination to discuss their strategies and thinking processes while using these games. The large number of available games facilitates them being more readily tailored toward teaching specific skills. Due to the variety of short-form games, they are more readily modifiable for an individual student's interest and skill levels. Short-form games can be completed in a classroom period, and because most of them are freely available on the Internet or as apps on a tablet device, they can be practiced outside of the classroom as "homework." Once a number of short-form games are identified as practicing the same skill, others can be assigned as homework to reinforce and generalize the skills. This type of repetition with different games has been demonstrated to improve the transfer of game-based skills to the real world (Mackey et al., 2011).

## **Best Practices**

Successfully utilizing games and apps in the classroom to teach 21st century, executive functioning, and creativity skills requires that educators familiarize themselves with some of the basic literature on game-based learning. It is also necessary that games and apps be integrated into classroom goals so there is a clear rationale for the use of these technologies. While teachers do not have to be experts in playing the individual games, they should have some knowledge about game mechanics and how a particular game can be used to practice a skill. Perhaps more important is teacher knowledge that helps to generalize game-based learning into effective classroom learning. While classroom use of video games and apps is in earliest stages, there are a number of promising tools to help teachers select appropriate games, have a curriculum for using those games, and connect these games to larger academic and learning goals.

## **Resources**

### **Research Labs**

The Education Arcade

GlassLab

Partnership for 21st Century Skills (P21)

### **Researchers**

Eric Klopfer

Scot Osterweil

Jennifer Grogg

Jason Haas

James Paul Gee

## Websites

The Learning Games Network (LGN) (<http://www.learninggamesnetwork.org/>)  
LearningWorks for Kids (LWK)([www.learningworksforkids.com](http://www.learningworksforkids.com))  
Common Sense Media ([www.common Sense Media.org](http://www.common Sense Media.org))  
Graphite (by Common Sense Media) (<http://www.graphite.org/>)  
The Partnership for 21st Century Skills (<http://www.p21.org/>)  
Teach with Portals (<http://www.teachwithportals.com/>)  
MinecraftEdu (<http://minecrafte du.com>)

## Games

*Angry Birds*  
*Blobber*  
*Bloxorz*  
*Civilization*  
*Crayon Physics* (<http://www.crayonphysics.com/>)  
*Legend of Zelda: Twilight Princess*  
*Metal Gear Solid*  
*Mincecraft* (<https://minecraft.net/>)  
*Portal 2* (<http://www.thinkwithportals.com/>)  
*Silversphere*  
*World of Warcraft*

## References

- Adachi, P., & Willoughby, T. (2013). More than just fun and games: The longitudinal relationships between strategic video games, self-reported problem solving skills, and academic grades. *Journal of Youth and Adolescence*, 42(7), 1041-1052.
- Association of American Colleges and Universities (AAC&U). (2014). *VALUE: Valid Assessment of Learning in Undergraduate Education*. Retrieved from <http://www.aacu.org/value/rubrics/>.
- Baniqued, P., DeSouza, S., Hyunkyu, L., Severson, J., Voss, M., Salthouse, T., Chandramallika, B., and Kramer, A. (2013). Selling points: *What cognitive abilities are tapped by casual video games?* *Acta Psychologica*, 142, 74-86.
- Barkley, R. A. (2012). *Executive functions: What they are, how they work, and why they evolved*. New York, NY: Guilford Press.
- Brown, H. J. (2008). Modding, education, and art. In *Videogames and education* (pp. 155-170). New York: ME Sharpe.
- Brown, T. E. (2013). *A new understanding of ADHD in children and adults executive function impairments*. New York, NY: Routledge.
- Clarfield, J., & Stoner, G. (2005). The effects of computerized reading instruction on the academic performance of students identified with ADHD. *School Psychology Review*, 34(2), 246-254.
- Cornally, S. (2012, November 30). Video games in the stem classroom. Edutopia. Retrieved September 2013, from <http://www.edutopia.org/blog/video-games-in-STEM-classroom-shawn-cornally>.
- Critical Thinking Co. (2014) *Cornell Critical Thinking Tests*. Retrieved from <http://www.criticalthinking.com/cornell-critical-thinking-tests.html>.
- Diamond, A. (2012). Activities and programs that improve children's executive functions. *Current Directions in Psychological Science*, 21(5), 335-341.

- Diamond, A., Barnett, S. W., Thomas, J., Munro, S. (2007). Preschool program improves cognitive control. *Science*, 318(5855), 1387-1388.
- Educational Testing Service. (2014) The iSkills™ Assessment. Retrieved from <https://www.ets.org/iskills/about>.
- Galinsky, E. (2010). *Mind in the making: The seven essential life skills every child needs*. New York, NY: Harper Collins.
- Gee, J. P. (2004). *Situated language and learning: A critique of traditional schooling*. New York, NY: Routledge.
- Gee, J. P. (2007). *What video games have to teach us about learning and literacy* (2nd ed.). New York, NY: Palgrave Macmillan.
- Gee, O. (2013). Swedish school makes Minecraft a must. *The Local*. Retrieved September 2013, from <http://www.thelocal.se/45514/20130109/#.UPPkIGdZO2q>.
- Goldberg, E. (2001). *The executive brain: Frontal lobes and the civilized mind*. New York, NY: The Oxford University Press.
- Green, C. S., Sugarman, M. A., Medford, K., Klobusicky, E., & Bavelier, D. (2012). The effect of action video game experience on task-switching. *Computers in Human Behavior*, 28(3), 984-994.
- Greenstein, L. (2012) Beyond the core: Assessing authentic 21st century skills. *Principal Leadership*, 13(4), 36-42.
- Insight Assessment. (2013) *California Critical Thinking Skills Test (CCTST)*. Retrieved from <http://www.insightassessment.com/Products/Products-Summary/Critical-Thinking-Skills-Tests/California-Critical-Thinking-Skills-Test-CCTST>.
- International Society for Technology in Education. (2012) ISTE and the ISTE Standards. Retrieved January 2014 from <http://www.iste.org/standards>.
- Kane, M., Berryman, S., Goslin, D., & Meltzer, A. (1990). *The Secretary's Commission on Achieving Necessary Skills: Identifying and describing the skills required by work*. United States Department of Labor. Retrieved September 2013, from <http://wdr.doleta.gov/SCANS/idsrw/idsrw.pdf>.
- Kow, Y.M. & Nardi, B. (2009) Culture and creativity: World of Warcraft modding in China and the US. In W. S. Brainbridge (Ed.), *Online Worlds : Convergence of the real and the virtual* (pp. 21-42). London, UK: Springer-Verlag.
- Kulman, I., Stoner, G., Ruffolo, L., Marshall, S., Slater, J., Dyl, A., and Cheng, A. (2010). Teaching executive functions, self-management, and values through popular video-game play. In Schrier, K. and Gibson, D. (Eds), *Designing games for ethics: Models, techniques and frameworks*. Hershey PA: IGI Global.
- Mackey, A. P., Hill, S. S., Stone, S. I., & Bunge, S. A. (2011). Differential effects of reasoning and speed training in children. *Developmental Science*, 14(3), 582–590.
- McClelland, M. M., Cameron, C. E., Connor, C. M., Farris, C. L., Jewkes, A. M., Morrison, F. J. (2007). Links between behavioral regulation and preschoolers' literacy, vocabulary, and math skills. *Developmental Psychology*, 43, 947-959.
- TeacherGaming, LLC. (n.d.) *MinecraftEdu.com: Bringing Minecraft to the classroom*. Retrieved September 2013, from <http://minecraftedu.com/>.
- National Governors Association Center for Best Practices & Council of Chief State School Officers. (2010). *Common core state standards: English language arts standards*. Retrieved September 2013, from <http://www.corestandards.org/the-standard>.
- Noddings, N. (2005). What does it mean to educate the WHOLE CHILD? *Educational Leadership* 63(1), 8-13.
- Ota, K. R., & DuPaul, G. J. (2002). Task engagement and mathematics performance in children with attention-deficit hyperactivity disorder: Effects of supplemental computer instruction. *School Psychology Quarterly*, 17(3), 242-257.
- Pearson education. (2012) *Watson-Glaser Critical Thinking Test*. Retrieved from <http://www.thinkwatson.com/assessments/watson-glaser>.

- Perrotta, C., Featherstone, G., Aston, H., & Houghton, E. (2013). *Game-based learning: Latest evidence and future directions* (NFER Research Programme: Innovation in Education). Slough, Berkshire: National Foundation for Educational Research.
- Reeves, B., Malone, T. W., & O'Driscoll, T. (2008). Leadership's online labs. *Harvard Business Review*. Retrieved September 13, 2013, from <http://sm.avito.nl/wp-content/uploads/2013/02/Reeves-B.-T.-Malone-T.W.-O%E2%80%99gDriscoll-2008-Leadership%E2%80%99s-online-labs-Harvard-business-review-vol.-86-no.-5.pdf>.
- Rideout, V. J., Foehr, U. G., & Roberts, D. F. (2010, January). Generation M2: Media in the lives of 8- to 18-Year-Olds. *The Henry J. Kaiser Family Foundation*. Retrieved September 27, 2013, from <http://kaiserfamilyfoundation.files.wordpress.com/2013/04/8010.pdf>.
- Schoen, L. & Fusarelli, L. D. (2008). Innovation, NCLB, and the fear factor: The challenge of leading 21st-century schools in an era of accountability. *Educational Policy*, 22(1), 181-203.
- Scholastic Testing Service (STS). (2013) *Torrance Tests of Creative Thinking (TTCT)*. Retrieved from <http://www.ststesting.com/ngifted.html>.
- Shaffer, D.W. (2006). *How computer games help children learn*. New York, NY: Palgrave Macmillan.
- Silva, E. (2009). Measuring skills for 21st-century learning. *Phi Delta Kappan*, 90(9), 630-634.
- Squire, K. (2008). Open-ended video games: A model for developing learning for the interactive age. In Katie Salen (Ed.), *The ecology of games: Connecting youth, games, and learning* (pp. 167-198). Cambridge, MA: MIT Press.
- St. Jean, M. (2013, February 10). 21st century skills, gamification, and Minecraft. *Think (Ed + Tech)*. Retrieved September 2013, from [http://thinkedtech.blogspot.com/2013/02/21st-century-skills-gamification-and\\_10.html?q=21st+century+skills](http://thinkedtech.blogspot.com/2013/02/21st-century-skills-gamification-and_10.html?q=21st+century+skills)
- Steinkuehler, C. A. (2004). Learning in massively multiplayer online games. In *Proceedings of the 6th international conference on learning sciences* (pp. 521-528). International Society of the Learning Sciences.
- Valve Corporation. (2013). *Teach with portals*. Retrieved September 2013, from <http://www.teachwithportals.com/>.
- The Partnership for 21st Century Skills. (n.d.). Retrieved September 13, 2013, from <http://www.p21.org/>.
- Trilling, B., & Fadel, C. (2009). *21st century skills: learning for life in our times*. San Francisco, CA: Jossey-Bass.
- U.S. Department of Education. (2013). *No child left behind*. Retrieved from <http://www2.ed.gov/nclb/landing.jhtml>
- Thoughtful learning. (n.d) *What are 21st century skills?* Retrieved September 13, 2013, from <http://www.thoughtfullearning.com/resources/what-are-21st-century-skills>.
- Willoughby, M., Wirth, R. J., & Blair, C. (2012). Executive function in early childhood: Longitudinal measurement invariance and developmental change. *Psychological Assessment*, 24(2), 418-431.