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Videogames and Learning

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1. Introduction

By most measures, the videogames industry has flourished over the decade. In 2010 in America alone, total consumer spending on the games industry in totaled $25.1 billion (Siwek, 2010), surpassing both the music industry ($15.0 billion) and box office movies ($10.5 billion). It is also one of the fastest growing industries in the US economy: From 2005 to 2010, for example, the videogames industry more than doubled while the entire United States GDP grew by about 16 percent. The amount of time young people spend with entertainment media in general is staggering. Youth ages 8 to 18 year olds consume about 10.45 hours per day of media compressed into 7.38 hours per day thanks to multitasking (Rideout, Foehr, & Roberts, 2010). Console and handheld videogames alone account for roughly 1:13 of that screentime, not including computer games. And the majority of unit sales come from games targeted at children, with ESRB ratings of E for everyone (56% of unit sales), E10+ for ages 10 and up (18%), or T for ages 13 and up (21%) (Entertainment Software Association (2011). Obviously video games capture a great deal of time and interest from school aged youth.

But the sheer popularity of videogames with young people is not the primary reason that learning scientists have taken an interest; rather, it is their capacity to effect cognitive and behavioral change. Empirical findings on the impact of games come from a broad range of academic disciplines, including neuroscience, social studies education, literacy studies, health, and psychology. Action games have been found to improve visual acuity & attention (Green, Pouget, & Bavelier, 2010). Historical simulations aid systems understanding in world history & geography (Squire & Barab, 2004). Exergames like *Dance Dance Revolution* or *Nintendo's Wii Sports* are shown to increase calorie expenditure and decrease sedentary lifestyles for children (Graf, Pratt, Hester, Short, 2009). Casual games like *Bejeweled II* have been shown to increase mood and decrease stress (Russoniello, O'Brien, & Parks, 2009). Videogame related texts for titles like *World of Warcraft* enable struggling readers to perform on par with their more successful counterparts despite the fact that game related texts typically read at the high school level (11.8 grade level text) (Steinkuehler, 2012). Online game community discussion boards evidence scientific reasoning (Steinkuehler & Duncan, 2008). The 3D puzzle platform *FoldIt* has leveraged crowdsourcing against particularly knotty problems in research on protein structures to make genuine scientific discoveries – the findings of which have been published in *Nature* and other leading science journals with the players listed as authors (Eiben, et al, 2012).

Across these studies, several themes emerge. First, videogames are remarkably engaging for the audience who plays them. Few media have been charged with "addiction" to the extent that games have, and their interactivity and design principles are at the core of their appeal. Second, commercial games oftentimes already exemplify good pedagogy (Gee, 2010): Built into the beginning levels of all successful commercial games are principles for learning that enable players to successfully master not just the game system and interface but game goals and rules. The fandom communities associated with successful titles show similar learning principles at work, the activities of which complement not just the game content but the in-game learning mechanics as well. Third, games afford opportunities for learning assessment that are quite rich, ranging from learning analytics applied to a given game title's data exhaust (telemetry or clickstream data) to connected ethnographies that trace student trajectories of learning from within the game to the online game fandom community to participation structures in the in the home or classroom and back again (see Kafai and Dede's chapter on virtual worlds, this volume). Fourth and finally, their widespread popularity and existing online distribution channels offer tangible means for their potential scale.

These themes raise considerable interest in the medium for use in learning, both within formal classrooms and beyond them, in after-school programs and home. In this chapter, we review the extant literature on videogames and learning, organized in terms of the functional roles in which videogames are typically positioned: (2.1) as content providers, (2.2) as bait for other forms of valuable intellectual activity, (2.3) as vehicles for assessment, or (2.4) as architectures for engagement whose design characteristics can be applied to other content and/or activity domains. We close with a discussion of the recent debate on evidence and the current challenges and trends in the area.

2. The Roles that Videogames Play

Videogames have played multiple various roles in learning depending on factors such as context, goal, participant structure, nature of the videogame used, topically relevant theme, and demographic population. Compare, for example, the use of the historical simulation game *Civilization IV* to teach global material geography to high school students in an AP history course (McCall, 2011) versus the use of the massively multiplayer online game *World of Warcraft* as a context for interest-driving reading in an after school program for struggling readers. In the former, the role of the game is as a content provider and the measure of its effectiveness is contingent on appropriate use in terms of accuracy of the model and structured pedagogical activities linking it to additional resources and AP History content standards. In the latter, the role of the game is as an organizing participation structure and the measure of its effectiveness is contingent on not the accuracy or relevance of its content but rather the degree to which it effectively motivates its players to tackle texts with the right feature (complexity, vocabulary, etc). One measure of the effectiveness for the former might be whether players can critique the simulation underlying the game. For the latter, a better measure might be whether or not the game is motivating enough to get struggling readers to keep reading even when its hard. This section details these key roles.

2.1. Games as Content

Perhaps the most common conception of the role of videogames in learning is as the content to be learned – most typically as content knowledge and skills but at times including dispositions as well. Games have been used in nearly all domains for learning, from mathematics (*DragonBox*, *DimensionM*) to health (exergaming titles such as *Dance Dance Revolution*). In this chapter, we focus on three example areas to highlight the general tenor of research and design across the various content domains: history, science, and language learning.

The commercial market success of historical simulation games like the *Civilization* series, *Assassin's Creed*, and *Rome: Total War* has inspired learning scientists to test the meddle of games for learning for nearly a decade. Engaging simulations of world history or specific historical periods promise the capacity for students to "replay history" (Squire & Barab, 2004), whether on the global material scale (where example gameplay mechanics include development of stable cities, allocation of resources, or negotiations with competing civilizations) or the local scale (where example gameplay mechanics include role-play as a historical figure, navigation of historical villages and terrain, and re-enactment of key battles or negotiations with other historical figures). In a study by Moshirnia and Israel (2010), modified in-game maps in Civilization IV to represent real world maps were used to, in addition to customized information displays and pop-ups, as instructional history content related to the American Revolutionary War. The authors found that such treatments can indeed be effective for developing students' content knowledge and retention. Additional studies of the impact of history games confirm these findings and demonstrate that such media have the capacity to engage students beyond traditional methods (Devlin-Scherer & Sardone, 2010; Squire & Barab, 2004; Watson, Mong, & Harris, 2011), particularly in combination with skilled teaching and implementation (Lee & Probert, 2010; Squire, 2005; Squire, DeVane, & Durga, 2008). Engaging students in reflection on their gameplay and comparisons between it and actual historical accounts shows great promise for a more nuanced understanding of history content (Charsky & Mims, 2008), highlighting the limitations of any simulation or model, its misconstruals and inaccuracies.

Perhaps the most well known use of games as content is in the domain of the sciences, in part due to the national attention brought to the subject through the 2011 National Research Council (NRC) report. Commercial science games like *World of Goo* and non-commercial titles like *FoldIt* or *Citizen Science* have captured both public and research attention, with debates on both sides as to the proper role of games in science content learning. According to the NRC (2011), "Simulations and games have great potential to advance multiple science learning goals, including motivation to learn science, conceptual understanding, science process skills, understanding of the nature of science, scientific discourse and argumentation, and identification with science and science learning." (p.25) The key word here, however, is "potential." After examining the evidence, the committee concluded that the evidence for the effect of games on conceptual understanding was emerging but inconclusive and for science process skills and discourse was inconclusive. Although the report was published in 2011, the committee review of the literature was in 2009. Much research and development has happened since that time; our discussion in section 3 below "Debate on Evidence of Effectiveness" details these new conclusions.

The third and final example domain for games as content is in language learning, perhaps the most overlooked yet powerful means to which games have been leveraged to date. Example titles include larger game worlds like *XENOS* as well as smaller treatments such as XXX. Evidence for dramatic gains is consistent across multiple meta-analyses and reviews, including Peterson (2010), Young et al (2012) and Wouters, van Nimwegen, van Oostendorp, & van der Spek, 2013). The rich multimodal environments that games provide function to ground language learning is the situated context of its meaning and use (Gee, 2010), thereby enabling meaningful language acquisition to take place. They allow the grounded use of language in a rich context, both virtually and, in many cases, socially. Young et al (2012) add that the current paradigm for language learning instruction, with its focus on immersive experiences and social interaction, is a very good match for the affordances that games provide.

2.2. Games as Bait

While videogames can indeed successfully serve as interactive content within the right domains (like science), this is certainly not their only function in contexts for learning. Recent studies show that engagement in commercial, off-the-shelf titles not intended to teach and with no direct representation of the target domain within them, can, under the right conditions, promote valued forms of thinking and learning. Such results have surfaced across a range of disciplines and research areas, including perception and attention (Green & Bavelier, 2003), collaborative problem solving (Squire, Giovanetto, DeVane, & Durga, 2005; Steinkuehler, 2005), digital and print literacy (Gee, 2010; Leander, & Lovvorn, 2006; Steinkuehler, 2006, 2007, 2008a, 2012), computer and information technology fluency (Hayes, 2008), history (Squire, DeVane, & Durga, 2008), systemic thinking (Squire, 2005), ethical reasoning (Simkins & Steinkuehler, 2008), and science reasoning (Steinkuehler & Duncan, 2009). As a medium, all games turn screen time into problem solving due to their fundamentally interactive nature. In a game, nothing at all happens until the player makes a move (a choice). Thus, even games whose content is not overtly educational can and frequently do require intellectual practices that are thoroughly educational. Moreover, as Young et al (2012) points out, "Much of the 'learning' of video game play may come from affinity groups that emerge from game play, consisting of metagame sources such as blogs, wikis, and discussion pages that support hints, cheats, and modding" (p. 82-83). Such "metagame" community and sources themselves can prove efficacious for learning even when the game title on which they focus is purely for entertainment.

The capacity of games to recruit intellectual work in the service of "beating the game" enables them to generate new configurations of various intellectual activities by placing those activities in the service of new, interest driven and highly engaging goals of play. Classic examples include the ways in which fantasy baseball recruits statistical reasoning (Halverson, 2008), how *The Sims* game franchise recruit media production and storytelling (Gee & Hayes, 2010), or how online games recruit important forms of leadership (Brown & Thomas, 2006). In many cases, the online community of a game title's fans functions as a kind of intellectual community, promoting valued forms of knowledge and skills among the players. For example, in one study (Steinkuehler & Duncan, 2008), analysis of a representative sample of discussion board forum posts for the commercial games *World of Warcraft* found that 86% of the forum discussions were posts engaged in ''social knowledge construction'' rather than social banter. Over half of the posts evidenced systems based reasoning, one in ten evidenced model-based reasoning, and 65% displayed an evaluative epistemology in which knowledge is treated as an open-open-ended process of evaluation and argument (the very attitude toward knowledge that one needs if one is to value science at all). In other cases, the texts and other artifacts used to do well in a given videogame function as accidental instructional material of sorts. In Steinkuehler (2012), texts regularly involved in videogame play were found to be primarily expository in nature, with an 11.8-grade reading level and 4% academic vocabulary. When reading performance on game-related versus school-related texts was compared using level-appropriate texts on assigned topics, no performance differences were found. However, when participants were allowed to choose topics, so-called struggling readers performed 6.2 grade levels above their diagnosed competency due to doubled self-correction rates. Thus, game-related reading may be particularly efficacious for readers identified as struggling in school—not because such reading is games-related but because it is interest-driven, fostering persistence in the face of textual challenges among students who might otherwise disengage.

A second notable use of games as a kind of bait is the use of games as *preparation for future learning* (Belenky & Nokes-Malch, 2012; Bransford & Schwartz, 1999). Here, games are positioned before the target domain to be learned as a way to provide players vicarious, hand-on experience with the phenomenon or domain under study. In this use case, gmeplay serves to prime student to subsequently tackle instructional materials in more traditional forms (Hammer & Black, 2009; Reese, 2007). The work of Arena (2012) is a case in point: In this study, community-college students were randomly assigned to receive and play one of two commercial games (*Call of Duty 2*, a first person shooter, or *Civilization IV*, a historical simulation game) over a period of five weeks as preparation for learning from a lecture about World War II. Participants in the control condition received no game as preparation. Comparison of pre- and post-lecture tests indicated no condition differences in performance on the pre-lecture test but a significant positive effect of gameplay on the post-lecture test. As hypothesized, playing videogames had prepared students to learn more from the lecture. Additional analysis showed that the two game titles had differentially influenced participants' attention, with the first-person shooter players paying more attention to local tactical elements and historical simulation players attending more to global strategic elements. Thus, recreational gameplay, under the appropriate conditions, can help students learn from more traditional materials.

2.3. Games as Assessment

Because game structure learning in the process of problem solving, and often require players to mobilize a variety of intellectual resources, there is widespread interest in investigating their potential to transform assessment. Gee (2005) observed that we would never think of applying a "test" to assess learning in a game like *Halo*; the game itself assesses your understanding as you play. The general hope is that with the shift from a print-based educational media market to a digital one, educational researchers and assessment experts can capture the "data exhaust" of students' choices in online environments and better deliver content and assess learning (Schoettler, 2012). Tracking and modeling student performance, it is hypothesized, will better enable both the design and delivery of instruction and assessment (Gee, 2010; Shute & Becker, 2010). The general idea (perhaps best realized by Levy and Mislevy, 2004) is that simulation games could be closely aligned to content standards, could give just-in-time feedback on performance, and present data on problem-solving in situ that would be far superior to those data gathered through traditional measurement instruments such as tests. Research can demonstrate learning gains for students (Barab, Gresalfi, & Ingram-Noble, 2010), and can even correlate in game success to learning gains, but the idealized vision of an educational game that compels learners to achieve demonstrable excellence through their own volition remains elusive (Klopfer, Osterweil, & Salen 2009).

Thusfar, such techniques have been applied primary to "Discovery Games," such as *Fold.it*, or games with relatively constrained paths, such as Cisco Systems Aspire (which was designed through Evidence Centered Design, Behrens et al., 2004; Honey & Hilton, 2011). Recent developments in machine learning offer compelling techniques for measuring learning in game-based learning environments (Gee, 2004; Dangauthier, Herbrich, Minka, & Graepel, 2008). Machine learning techniques, including supervised and unsupervised techniques such as include reinforcement learning and semi-supervised regression are hypothesized to have dramatic potential for reshaping the design of learning systems. As educational systems move toward digital content delivery through mobile systems, it appears certain that such machine learning techniques will be applied to studying learning; bigger questions surround what these learning experiences will look like, how learning will be assessed, and what role different stakeholder groups (learning scientists, academics, teachers, parents, students) will play in shaping it.

An area currently being explored is how to apply such techniques to open-ended games that feature problems that can be solved multiple ways, construction or design tasks, and social mechanics in which learners interact online (Owen & Halverson, in press). Owen and Halverson investigated students playing *ProgenitorX*, a stem cell construction game, and found that efficient game play on the final levels was a predictor of learning gains more broadly. Owen and Halverson are currently applying this framework to other games, and posit that it may be a generalizable model toward using "in game data" (called telemetry data) for assessment. Their current work seeks to link games through common data structures so that researchers can identify play patterns *across* games, so that researchers can study (for example) if success on one game predicts success in another.

2.4. Games as Architectures for Engagement

Digital games have long been studied as sites of engaged learning (Gee, 2007; Malone & Lepper, 1985). Malone (1981) studied themes in Atari games toward developing a theory of intrinsic motivation and concluded that games use fantasy, control, challenge and curiosity to motivate players. Later, Malone and Lepper (1987) explored the social context of gameplay, and added collaboration and competition as other intrinsic rewards. Cordova and Lepper (1996) designed games leveraging these principles for mathematics learning, finding that more highly motivated students performed better than their peers on similar mathematics tasks.

In the 2000s, socially situated learning theorists studied games as architectures for engagement, using primarily through phenomenological, ethnographic, and discursive methods (Davidson, 2011; Gee, 2007). Consistent with this socio-cultural approach this work has examined game play as complex systems, seeking to understand how and why people play games, and how games are designed as systems to be learned (Steinkuehler, Squire, & Barab, 2012). As games have become larger and more complex, good design principles, such as providing just-in-time instruction emerged (Gee, 2005; 2007). Starting perhaps with Half Life (1998), games began jettisoning their lengthy tutorials and manuals. (The manual for *Civilization III,* one of the last of such games to be built this way, is 236 pages, Squire, 2006). In the hypercompetitive marketplace of entertainment games, these techniques evolve rapidly so that features such as embedded tutorials, just-in-time instruction, or adaptive Artificial Intelligence (AI) become expected in the marketplace (Sawyer, 2003). Tracking these design innovations across multiple games and platforms is challenging, and Davidson (2011) developed the *Well Played* journal as a venue for publishing venue in response in response. In well played pieces (which is analogous to being "well read"), authors unpack game design features through deep analysis of select titles. Davidson (2011) and later Davidson and LaMarchand (2012) develop a model of engagement in games that describes a player process of *involvement*, *immersion*, and *investment*. Analyzing *World of Goo*, and later *Uncharted 2*, Davidson demonstrates how specific narrative features contribute to player immersion.

A second branch of research uses character theory to investigate player types (Bartle, 2003). Originally developed through a grounded analysis user forum interactions, Bartle's (1996) theory emphasizes multiple, discrete motivations for game play (exploration, achievement, competition, and socialization), which one might in engage in at any time. Yee (2006) conducted a factor analysis of game players and proposed an alternative model based on three core motivations (with sub-factors): *Achievement*, *Social*, and *Immersion.* Yee's model describes these as *components*, as opposed to *types*, suggesting that they these components fit along a normal distribution, complement one another (as opposed to supplanting one another), and cluster so that a player is a configuration of a cluster of these components. This work reminds learning scientists, particularly those designing games for learning, that different players come to games with different motivations, and designing games to capture broad segments of the population is a challenge.

More recently, *gamification* has arisen as a term that describes using game thinking and game mechanics in non-game contexts to engage users (Deterding, 2013). These techniques include narrative structures, quests and challenges, point systems, and achievements. 5th Dimension is one of the longest running, and most well researched "gamification" type learning systems (Cole, 2006). The 5th Dimension was created in the 1990s as a mechanism for exploring Cole's (1996) theory of cultural psychology. In 5th Dimension "clubs" groups of 5-14 youth work through a maze of quests, which are assigned to them by a fictional wizard. These quests are presented on task cards, and frequently are based on a game such as *Carmen San Diego*, *The Incredible Machine*, or *Oregon Trail*. All learning is situated within a narrative experience of helping the wizard, rather than earning grades or points. Adults (usually college students) play *Wizard's Assistants*, who work as mentors for Over 100 research studies and evaluations have been conducted on the 5th Dimension, which has been enacted in sites across the world (Cole, 2006; Mayer, Blanton, Duran, & Schustack, 1999; Simmons, Blanton, & Greene, 1999). Through participation in Fifth Dimension, students develop academic skills that can be used across a variety of contexts (Blanton, Moorman, Hayes, Warner, 1997; Mayer, Quilici, Moreno, et al., 1997).

Subsequent projects, such as *Quest Atlantis*, have created a similar metaverse (that of Atlantis), but built around social commitments such as respect for diversity or creative expression (Barab et al., 2005). *Quest Atlantis* targets late elementary school students across a broad swath of the curriculum. Quest Atlantis is rendered in real-time 3D (first in Active Worlds, more recently in Unity) and through completing quests, students seek to improve life for these citizens. The quests range from online to offline behaviors, and are usually certified by a teacher through an online dashboard. Students' online profile includes features such as an item inventory, reputation systems, various currencies and so on. Most Quest Atlantis quests are traditionally-valued academic practices, but are given meaning through a narrative of the Atlantians, communicated via quests. The questing structure also serves as a *motivational* metagame that repositions learning even traditional academic *tasks* as a new *activity (*Barab, Zuicker, & Warren, 2007). Barab, Thomas, Tuzu and colleagues (2004) describes how students participating in Quest Atlantis were motivated by identity, play, immersion, and social relationships, which for some students, transformed academic activity from reward-based activity to activity driven by a desire to become new kinds of people, to play, or to engage in legitmate social activity. Through its many iteractions designers Barab, Arici, and Jackson (2005) find that the Quest Atlantis *narrative* was its most engaging feature. Studies of Quest Atlantis use in classrooms show that it can improve students' scientific inquiry, reasoning, and argumentation skills, along both traditional and performance measures (c.f. Hickey, Ingram-Noble, & Jameson, 2009). Barab and colleagues describe this process as "narratizing the curriculum," which suggests one useful way for designers to think about gamifying formal curricular structures.

3. Debate on Evidence of Effectiveness

Despite nearly a decade of interest in videogames as learning technologies in the field of learning sciences, a debate remains as to the evidence of their effectiveness. Several reviews of their impact have been attempted but their conclusions are inconsistent. Vogel et al. (2006) found that games outperformed more traditional methods in terms of both cognitive and attitudinal effects, but their results were mitigated by variables such as gender and whether navigation through the content was self-driven or teacher or computer driven. Ke's (2009) review of 89 articles found that games indeed to appear efficacious for learning but the evidence base is contradictory in places with treatments largely underspecified. Clark, Yates, Early, & Moulton (2010), on the other hand, found that serious games are not more effective than instruction methods at all. In contract, Sitzmann's (2011) meta-analysis found that games compared to controls effected 20% higher self-efficacy, 11% higher declarative knowledge, 14% higher procedural knowledge, and 9% better retention – but only when the comparison treatment elicited passive and not active learning.

Two very recent meta-analyses warrant a bit more discussion and help to tease out these contradicting conclusions in useful ways. Young et al (2012) conducted a meta-analysis of the relationship between learning games and academic achievement across the body of literature on game implementations in K-12 classrooms. Of the 363 articles found, however, only 10% were included (3 in history, 8 in math, 7 in physical education, 11 in science, and 10 in language learning) due to the under-specification of both the treatment variable (i.e. no clear gaming mechanisms were described) and the school-related dependent variable. The authors conclude that there is indeed evidence for positive effects of videogames on language learning, history, and physical education (specifically exergames), but little support for the academic value of video games in science and math. This insufficient evidence in the domain of science is corroborated in National Research Council's (2011) report.

In a second meta-analysis by Wouters, van Nimwegen, van Oostendorp, and van der Spek (2013), the authors analyzed the results from 39 studies comparing games to more conventional instruction methods (lectures, reading, drill and practice, and hypertext environments), the majority of which were conducted in the last five years, and found that games were indeed more effective than conventional methods in terms of both gains in both knowledge and cognitive skills and that the gains persist over time. Games were more effective when supplemented with other instructional methods and when played in groups rather than in isolation. Surprisingly, their results also showed that games are *not* more motivating than more conventional methods across the studies examined. The authors posit that the capacity of games to engage may well be mitigated in contexts where gameplay is mandatory or where the game mechanics are not well aligned with content and player choice within-game is compromised.

Why the debate on the evidence of effectiveness of games? Four complications make any reasonable summary of the empirical literature difficult. First and foremost, what technologies fall under the rubric of "games" itself is inconsistent: For Vogel et al. (2006), games include "interactive simulations." For Ke (2009), games are defined as computer based instructional games but simulations are not included because, according to the author, simulations do not involve competition. For Clark, Yates, Early, & Moulton (2010), the focus is on "serious games" yet there games are reviewed as one special case of discovery-based instruction more generally (and found wanting). In Sitzmann's (2011), the focus is on computer simulation games. In the NRC (2011) report, computer simulations and games are separate categories but both make the cut. Only Young et al (2012) and Wouters, van Nimwegen, van Oostendorp, and van der Spek (2013) give a principled, categorical definition to delimit what exactly is being reviewed and assessed – and even then there is reason to believe that, within those explicit definitions, there enough variation within category to raise serious question as to the merit of an conclusive statements as to effect.

Additional complications trouble efforts to review and summarize the research base. First, there is not enough specification across the body of research between game mechanics used and learning outcomes targeted (National Research Council, 2011; Young at al, 2012). Without drilling down to which specific game mechanics are being examined for effects in terms of what specific outcomes, substantive conclusions seem elusive. Second, because videogames are thoroughly interactive, individual players often have idiosyncratic goals and concomitant play patterns and therefore experiences of the so-called treatment (Harris, Yuill, & Luckin, 2008), making generalization within an across conditions difficult. As Young et al (2012) writes,

> current methodologies must extend beyond their current parameters to account for the individualized nature of game play, acknowledging the impossibility of the same game being played exactly the same way twice and establishing that game play may need to be investigated as situated learning. (p. 62).

Third and finally, the effects of games, like any other piece of instructional content, varies tremendously based on its context of use. This context includes not only the ways in which players tailor gameplay experiences to reflect their own preferences but also the social context, the paratexts and other game-related artifacts accompanying gameplay, the presence or absence of a more knowledgeable teacher or peer, and the degree of reflection or "metagaming" elicited. Like many other learning technologies, how effective games are is contingent on how thoughtfully they are employed.

4. Current Challenges & Trends

Throughout this discussion, three primary challenges emerge that should be address in order for research and design in the field of games for learning to move forward with success. First, the community would do well to submit to some working definition of games in order to get to the harder business of specifying mechanics and assessing their bearing on learning. Myriad definitions of games have been put forward in this and adjacent domains. In our view, perhaps the most straightforward and consensus definition in the literature is the definition provided by Klopfer, Osterweil, and Salen (2009) and used as the basis of the 2011 Science, Technology, Engineering, and Math (STEM) Video Game Challenge conducted by the U.S. Department of Education and the meta-analyses and reports by Thai, Lowenstein, Ching, and Rejeski (2009) and Young et al (2012) meta-analysis. Here, learning games are defined as:

> a voluntary activity structured by rules, with a defined outcome (e.g., winning/ losing) or other quantifiable feedback (e.g., points) that facilitates reliable comparisons of in-player performances…[that] target the acquisition of knowledge as its own end and foster habits of mind and understanding that are generally useful or useful within an academic context. Learning Games may be associated with formal educational environments (schools and universities, online or off), places of informal learning (e.g., museums), or self-learners interested acquiring new knowledge or understanding. (p. 11, 21) ”

Such a definition allows us to exclude other types of simulations and digital visualization tools while including other important forms of contemporary games such as alternate reality games (ARGs) played on mobile devices. This definition is also consistent with the work of Juul (2005) and others in the field of games studies more generally. Still, one caveat must be given: Even with this broad working definition in place, games may very well too broad a category for drawing useful generalizations. In Young et al's (2012) meta-analysis, for example, this definition of games is found to be still too large a grain size to meaningfully draw conclusions from as to their effects. Hopefully with this definition in place, however we can get to the harder business of definition what game mechanics and characteristics and for what learning effects.

A second challenges to the field of games for learning research and development is the situational and contextual factors that bear on game-based learning outcomes. Games need to be implemented with good teachers, who are able to scaffold performance, engage students in reflection, and draw connections between gameplay and other curricular materials (Baek, Kim, & Park, 2009; Young et al, 2012). Game-related learning takes place not only within the game technology itself but also and perhaps more crucially through the activities and materials (paratexts, artifacts, interactions, and activities) engaged in outside but in relation to the game. Debriefing and reflection practices in particular play an important role her as well as individual and peer review (Ke, 2008). In sum, overly narrow focus on the game technology itself may be a poor way to conceptualize where the locus of learning lies.

Moreover, the formal instructional context moderates the effectiveness of any game treatments as well (Sitzmann, 2011) and, in many cases, may very well be precariously aligned with the key affordances of games. In other words, there may well be a mismatch between the affordances of games and the structures of contemporary classrooms. As Young et al (2012) notes,

> there appears to be a disconnect between the possible instructional affordances of games and how they are integrated into classrooms. Games are often multiplayer and cooperative and competitive; they engage players in several hours of extended play, allow rich "hint and cheat" websites to develop around player affinity groups, and are played from weeks to years. However, most schools trade off extended immersion for curriculum coverage, individual play, and short exposures, goals that are not well aligned with engaging video game play. (p.80)

As the interest games and learning grows in the learning sciences, it will be important that, in an effort to fit games to existing classrooms, we do not end up unintentionally flouting the very features that make them provocative tools for thought in the first place.

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