Connected Gaming: Towards Integrating Instructionist and Constructionist Approaches in K-12 Serious Gaming

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Abstract: In this conceptual paper, we argue that K-12 serious gaming should focus on connected gaming, which is signaled by a move from a predominantly instructionist focus on having students *play* educational games for learning to an increasingly constructionist approach that has students *make* their own games for learning. Constructionist activities have always been part of the larger gaming ecology but have traditionally received far less attention than their instructionist counterparts. We argue that constructionist gaming approaches promote not only meaningful content and collaboration but also creative and critical skills in the context of coding. We propose that future discussions of serious gaming ought to be inclusive of constructionist approaches to better realize the full potential of gaming as a means to genuinely connect children to technology and to each other and how this potential for more meaningful connectivity can address the persistent access and diversity issues long facing gaming cultures.

Introduction

> Every educator must have felt some envy watching children playing video games: If only that energy could be mobilized in the service of learning something that the educator values. But the envy can take very different forms. Instructionists show their orientation by concretizing the wish as a desire for games that will teach math or spelling or geography or whatever. The Constructionist mind is revealed when the wish leads to imagining children making the games instead of just playing them. Rather than wanting games to instruct children they yearn to see children construct games.
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> *Seymour Papert (p. ii, 1995)*

Papert's assessment was remarkably prescient of developments that would follow just a decade later when the serious games movement started. Despite video games having become a multi-billion dollar business equaling—if not surpassing—the movie industry, gaming is still regularly dismissed by some educators as a waste of time, or even worse, an instigator of stereotypes and violence. In response to such critics, some theorists (Gentile & Gentile, 2008) have wondered that if video games are, in fact, such effective inculcators of stereotypes and violence, why can't their influence be harnessed for good and serve as powerful tools to support children's learning? This was the question that Gee (2003) answered when examining what video games could teach us about learning and literacy, arguing that many good educational principles—36 in total—could be found in the design and play of video games.

The launch of serious gaming realized the yearning for instructionist games, those games that are designed to teach academic content to students. Hundreds, if not thousands, of educational games and simulations have been designed to support learning in various domains (Shaffer, 2007; Squire, 2011). Accompanying these efforts were the launch of several conferences and journals, the funding of numerous research initiatives, and even the placement of a senior policy advisor on games and gaming in the White House. Following a report by the National Research Council (2011), a flurry of reviews have recently come out examining the learning benefits of instructionist games. The verdict reached by these meta-analyses is decidedly mixed: while one meta-analysis found significant impact (Wouters, van Nimwegen, von Oostendorp & van der Spek, 2013), others were more hesitant in their assessment of impact (e.g., Girard, Ecalle, & Magant, 2012; Vogel, Vogel, Cannon-Bowers, Bowers, Muse & Wright, 2013), while still others were downright dismissive of the motivation and cognitive benefits claimed by serious gaming (e.g., Young, Slota, Cutter, Jalette, Mullin, Lai, Simenoni, Tran & Yukhymenko, 2012).

There has however been one notable absence in all of these reviews: the inclusion of constructionist gaming approaches—namely those approaches in which games are designed by students rather than professionals for their learning benefits (Kafai, 1995; 2006). And this absence is surprising given the successes of constructionist gaming for not only learning programming but also academic content and other skills (see Hayes & Games, 2008). It is worth reflecting for a moment on what might have caused this omission. The first and most obvious reason stems back to what Papert aptly described as the instructionist desire of having a finished, downloadable, teaching product—namely, the game itself—as the party responsible (rather than the instructor) for teaching the child. A second and less inimical reason may be that constructionist gaming has been less popular simply because educators have viewed the endeavor as far too technical given its association with learning programming. And last, a third reason may be that until recently, the gaming industry did not want players to engage in any design or modification of the games they produced for the marketplace. However, whatever the reasons—educational, technical, or cultural—the situation is clearly changing.

We are currently witnessing a paradigmatic shift toward constructionist gaming that is propelled by several developments, including the initiative to promote computational thinking (Grover & Pea, 2013), a need to broaden participation in computing (NRC, 2011), and the emergence of a DIY culture (Lankshear & Knobel, 2010). But the central impetus for a shift comes from the industry itself. After all, some of the most popular games on the market today include level and character modding as a central feature (El Nasr & Smith, 2006) and encourage such modding as part of game play until the next version becomes available. This element of constructionism is not limited to gameplay itself. A closer examination of gaming cultures reveals that many rich learning activities happen in the context of what Gee (2003) refers to as "metagaming" in which play extends beyond the game and includes participating in online discussion forums (Steinkuehler & Duncan, 2008) and even accessing cheat sites (Kafai & Fields, 2013) to help players more effectively navigate the game. In the community of many instructional game designers, we also observe a recent shift to include game making platforms and activities (Klopfer & Haas, 2012). Perhaps though the clearest indicator that constructionist gaming has arrived is signaled by the remarkable popularity of Minecraft (Duncan, 2011), a virtual sandbox whose tremendous popularity has garnered over 12 million paying designers and even served as the topic of a recent South Park episode.

In this conceptual paper, we articulate a long overdue framework for constructionist gaming to outline its learning benefits in terms of coding, creativity, collaboration, and criticality. Through this framework, we make a case for connected gaming, an approach to serious gaming that includes both instructionist and constructionist perspectives such that playing and making games are no longer treated as two separate activities but overlapping, mutually informing processes for learning. Connected gaming, as we argue, sees learning to play and make games as part of a larger gaming ecology in which the traditional roles of game player and game maker are no longer treated as distinct entities. In the following sections, we first conceptualize how the four components, or 4 C's of constructionist gaming, manifest themselves in the game-making process, and then outline a sample scenario for connected gaming, before addressing some of the key challenges in making the process more accessible to non-programmers and traditionally underrepresented groups. Our goal is to focus on how the learning sciences of serious gaming can be more inclusive and informative for children by giving young players a greater hand in the design and production of video games.

The "4C's" of Constructionist Gaming

Our approach to constructionist gaming builds on prior efforts to understand how and what children learn in the process of designing and making digital media through computer programming (Kafai & Burke, 2014). While current developments situate game making in several different fields such as new media literacies (Gee, 2010), system-based thinking (Salen, 2007) and critical engagement with media (Buckingham & Burn, 2007; Pelletier, 2009), we draw on the broader notion of participatory culture informed by Jenkins and colleagues' (2006) work. We identify four different dimensions of participatory competencies—*c*oding, *c*reative, *c*ollaborative, and *c*ritical—that are all relevant to constructionist gaming (Kafai & Peppler, 2011) and underpin the nature of connected gaming.

Coding

Coding is the most distinctive skill to be learned, especially when compared to instructionist gaming which involves the mastery of complex interfaces but rarely to reaches beyond the surface of the screen itself. By their very design, digital games provide compelling systems precisely because they are not only one of the first systems a child encounters at an early age, but they remain a regular presence in children's lives, even as they graduate into adulthood. Video games are no longer meant for children only and as players grow older, they increasingly can appreciate the nuances of and the differences between various games. The design of the interface, the intuitiveness and responsiveness of game play, the way in which challenges are scaled to grow more complex and difficult—even where there are potential "cheats" within the game engine—all can be manipulated by the player. All of these functions are present in even the most rudimentary of video games and are optimal fodder for exploring the nature of systems, particularly when a player is not simply reacting to the system but also designing it.

Numerous studies over the last twenty years have shown what students can learn when coding games (e.g., Hayes & Games, 2008) using various programming tools such as Agentsheets, Alice, Flash, Logo, Scratch among others (Burke & Kafai, 2014). In a quasi-experimental study, Kafai (1995) showed that a class of upper elementary students who learned Logo programming in the context of game design activities over a three month time period improved significantly in writing and debugging programs when compared to students who were learning Logo programming solely in the context of smaller independent projects unrelated to gaming.

Supporting this initial research, several comparative pair programming studies (Denner & Werner, 2007) showed that pairs of Latina middle school girls outperformed students working on their own in learning programming concepts when designing games with Alice. Both designing and playing a video game alongside peer proved to be a crucial way that children understood the nature and function of code. The Globaloria network (Reynolds & Caperton, 2007), in which over thousands of students design video games as part of curricular activities in their schools, also demonstrated learning of key programming concepts using Flash. Even outside of school, a two-year study in a Computer Clubhouse found that use of programming concepts significantly increased from year 1 to year 2 (Maloney et al., 2008) as children increasingly developed and remixed video games for themselves and each other.

Foremost though, coding has received by far the most attention because it can include various software design practices ranging from programming, debugging, and remixing code. Taken together, these practices capture what has been described as “computational thinking” which Wing (2006) defined as designing systems for more effective problem solving. While computational thinking is not just coding, code represents one of the key avenues to engage youth in an early understanding about how effective systems are designed and maintained, a skill set that can be applied to fields as diverse as industrial mechanics, computational biology, and marketing analytics. Understanding game design is an optimal early incubator for grasping computational thinking as would be designers not only have to create a series of novel user interfaces but also need to ensure that these interfaces scale in complexity and even adjust to the player’s capacity to accomplished digitally-designed tasks. Coding in the context of constructionist gaming is not just learned for the sake of understanding and generating code, it also demands designers to be aware of perspectives other than their own and thus provides a rich context for collaboration, the next dimension.

Collaboration

The *collaborative* dimensions of constructionist gaming is often perceived in terms of the exclusive communities of “gamers” who are the self-professed experts in all things video games, much to the frequent annoyance of others and even to the isolation of themselves. Yet this die-hard group of those who "geek out" (Ito et al., 2009) around making and playing video games tend to overshadow a growing number of DIY communities that use programming as a core tool for creative media production, including robotics communities, e-textile communities, and programming communities like those that have evolved around Scratch, Arduino, and Processing languages. As large online communities have grown around more beginner-friendly tools like Alice, Scratch and Processing, they are marked by openness rather than what has traditionally been perceived as gamer exclusivity, with members regularly sharing ideas and remixing one another’s work. These new tools further reshape contemporary literacy practices in DIY communities, helping youth to meet the goals of becoming fluent with technologies, and extend computational thinking into computational participation (Kafai & Burke, 2014), in which solving problems and designing systems are not solely the function of algorithmic processes but more fundamentally representative of the practices and perspectives increasingly necessary to contribute within wider social networks and understand the cultural and social nature of a networked society.

This push for more collaborative endeavors around making video games becomes readily apparent with the plethora of new gaming challenges that have grown popular just over the past three years. The aforementioned Scratch website issues regular “collaborative challenges” and “collab camps” (Kafai & Burke, 2014) annually, as does Microsoft’s Kodu site with the “Kodu Cup” and Globaloria with its annual “Globey Awards” challenge. While each of these sites have their own rules and regulations for their respective competitions, all of these competitions foster the collaborative spirit by encouraging their challengers to post their ongoing projects for feedback from their peers and utilize discussion boards and forums to search out fellow team members and solicit advice on the game-making process. In the spirit of competition, collaboration (more tacitly) ensues—not unlike what we witnessed with the tremendous growth of science fairs over the second half of the 20th century in the U.S. Even the federal government appears to be tapping into the excitement of gameplay and competition, having sponsored the STEM National Video Game Challenge (http://www.stemchallenge.org) for the past three years. With the stated goal “to motivate interest in STEM learning among America’s youth by tapping into students’ natural passion for playing and making video games,” the Challenge is issued by none other than the President himself and can be utilized as a forum that K-12 schools can adopt to more effectively integrate collaborative STEM learning through a hands-on, project driven approach.

This constructionist context of making games for others adds a new collaborative dynamic to the more traditional instructionist approach to gaming in which the power of collaboration manifested itself in players playing with each other to advance the game. For instance, Gee (2003) brings up examples of how players have to coordinate in order to plan and successfully orchestrate many of the higher up challenges that no single player could can complete on his or her own. Likewise, Luther and Bruckman (2011) illustrate how in online creative communities, such as the popular game-making site Newgrounds, when collaborations succeed, they produce content that far supersedes what any single member could have made on his or her own. In these collaborative game-making activities, different expertise, not just technical but also team management and various creative artistic skills are needed, which leads to our next dimension.

Creative

Many of the creative practices involved in making games are rooted in the arts and can involve observing and deconstructing media, evaluating and reflecting gameplay, as well as referencing, reworking and altogether remixing other games (Hetland et al., 2007). These referencing, reworking and remixing practices include not only the creation of original works that make knowing reference to previous games, cartoons, music, and other sources of popular culture but also the modification of existing games, images or sounds, often to create entirely new interactive pieces or "machinima" such as non-interactive movies. With the advent of the so-called "web 2.0", youths' creative media production with digital media has increasingly entailed a great deal of reworking or remixing of popular media texts such as videogames and music (Kafai & Peppler, 2011).

Peppler and Kafai's (2007) case study of 15-year old Jorge well captures the potential for young game designers to not only learn coding and effective collaboration but also the creativity behind seamless imitation. Using Scratch at a Computer Clubhouse specifically geared toward low-income youth from the surrounding neighborhood, Jorge was a regular visitor to the Clubhouse over the eight-months of the ethnographic study. The second project he created was a video game entitled "Metal Slug Hell Zone X", a play off the popular "run and gun" video game series Metal Slug. Carefully coding each sprite within Scratch to respond promptly to keystrokes, Jorge fully recreated the avatar fluidity characteristic of the original game, exploring and— to a certain degree—reformulating the genre conventions of shooter games. Yet with this functionality established, Jorge did not stop. Instead, he spent numerous additional hours, drawing every character and animation from the original game using Scratch's paint feature, which in turn were based upon his own penciled sketches of the original video game. If, as Buckingham (2003) points out, "imitation is an indispensable aspect of learning" in media education, Jorge's own video game exemplifies the educational potential of such creative imitation (p. 134).

In observing creative practices as they pertain to constructionist gaming, young designers learn about and appreciate artistic principles by *making artistic choices* within a single modality (e.g., visual, audio, or kinesthetic), as well as by *connecting multimodal sign systems* across two or more modalities (e.g., visual and sound, visual and movement or gesture, and sound and movement) to convey an artistic idea (Peppler, 2013). In constructionist gaming, the creative dimension not only adds personal but also multimodal expressions into their designs. Some of these same elements of creative designs arise in instructionist gaming, such as when players have the opportunity to name and customize their avatars at the start of a game. While this may seem to be only a minor element, this ability to creatively customize a game has been one of the hallmarks of "good" instructionist games and points out that the creative dimension of serious gaming has always been inherently constructionist in nature.

Critical

The fourth and final component of constructionist gaming—criticality—may very well be the hardest to pin down since media and arts education have historically emphasized the consumption and appreciation of existing designs as their main goals rather than making anew through the critical remixing and repurposing of such designs (Peppler, 2013). Several approaches have examined game design as a way to involve youth in critically viewing media and using this understanding to create their own original work. As youth begin to take advantage of living in a digital world by capitalizing on the wealth of images, sounds, and videos accessible as "materials" to reuse in their own work, media educators grew particularly concerned about the ways in which youth are either re-inscribing or questioning existing dominant norms (Buckingham, 2003; Buckingham & Burn, 2007). These critical practices of game production include youth being able to critically reflect on and evaluate media texts, understanding references made in popular texts, and deconstructing and interpreting the meaning behind such texts. By observing the critical practices of game designers in this way, we gain an understanding of the extent to which young designers understand and question the popular texts that they incorporate in their work, apart from what they learn about software programming and the arts.

For instance, critical choices can take on the form of game designers intentionally removing all shooting features and enemies while keeping other features of a run-and-gun game genre intact (e.g., side-scrolling engine, smooth-action animation, core mechanics, etc.) to create a peaceful setting in a once violent videogame (Peppler & Kafai, 2007a). Popular DIY practices, like remixing, bring up important issues of ethics in new media literacies such as *crediting ownership* and *providing inside information*. Crediting ownership consists of referencing the intellectual origins of "text" used in media productions. And children can take this referencing quite seriously. In an after-school club, Scratch programmers ages 10-12 years were adamant that their fellow programmers credited the origins of programs that they had remixed and posted online. While Scratch programmers initially were concerned about other taking their programs, they also came to understand the remixes as a form of recognition that represented attention they received from others (Kafai, Fields, & Burke, 2010).

In the context of constructionist gaming, the process through which youth transform from players to creators of gaming also provides a critical lens, even in informal learning spaces (Burke & Kafai, 2014; Peppler & Kafai, 2007a). The extent to which these practices represent the larger community is unknown and is at the core of our rationale for investigating vast data sources that were amassed by multiple members of the community. As youth make a series of choices, this ultimately leads to more fuller forms of literacy as they become more practiced in these decision making processes. Some approaches in instructionist gaming have taken on more critical lenses by choosing topics such "World without Oil", which engages game players in critical examination of their own gas consumption by imagining over several weeks what life would be like with restricted or even absent resources; likewise, DeVane and Squire's (2007) study on how youth of different SES play Grand Theft Auto and use this to examine home ownership and other economic situations holds this element of personal critical reflection within an instructionist gaming context. Whether within an instructionist or constructionist context though, this fourth C of criticality is a crucial element to keep in mind whenever playing or making video games as games and gaming do not simply represent an escape from everyday life but also a reflection of our own lives and personal predilections.

Connected Gaming

We see the four C's—coding, creative, collaborative, and critical practices–to be present in both constructionist and instructionist approaches to gaming, and while some of these elements are more widely documented to occur in one approach over the other, these two approaches are nonetheless complimentary and serve as the basis for connected gaming. The well-known game SimCity and the newly released Scratch 2.0 program each offer an apt example of instructionist and constructionist approaches merging together into this notion of connected gaming. From the instructionist gaming side, SimCity illustrates how playing a game can contribute to a better understanding of the constantly shifting dynamics of a simulated world (Salen, 2013). From the constructionist gaming side, new features in Scratch 2.0 environment allow for writing programs that survey information from participants at the site to better understand who is sharing online and what they are sharing (Dasgupta, 2013). These are two different approaches, but both have the same goal of "looking under the hood" for understanding what happens in the massive and interconnected community. While the tools in SimCity are programmed by experts, the tools in Scratch are programmed by players themselves. Going forward, there is no reason that SimCity couldn't offer programmable tools that would allow end-users to customize their investigations, while pre-programmed tools in Scratch can be offered for those wanting to experience an actual simulation before designing their own. In fact, the latter approach already exists. Thus in bringing instructionist and constructionist approaches together, we open up new perspectives on using computation for understanding online participation in gaming.

To realize this potential of connected gaming, however, we face at least two critical challenges that have long faced gaming culture in an instructionist context: access and participation. The first issue stems from the lack of access to learning coding skills. While children may have the devices themselves, they have little to no understanding how the devices actually work. The second issue follows the first and addresses the strong disparities in participation as to who actually produces within both gaming and coding communities. These two issues have been particularly dicey issues for girls with girls' underrepresentation in both coding and gaming communities. Yet, in an unexpected development over the last decade, programming games has been used to broaden participation in computing for girls (Kafai et al., 2008).

From Tools To Communities in Connected Gaming

So can we capitalize on these developments to broaden access and participation? Making games is obviously not a simple enterprise but requires much, including dedicated chips, significant technical knowledge, as well experience in storytelling, art, and design. Can novices become such game designers? One of the key challenges is to provide them with tools that lower the barriers, or the floors (Burke & Kafai, 2014), to make the once-laborious process of computer programming. But by the same token, with the floor laid out, the next challenge becomes to what extent these various game-making tools have the capacity to *retain* their users. While "low floor" accessibility is the first step to ensure a steady number of novice users are accessing and using a game tool, designers also have to ensure that their game engine is robust enough to ensure more experienced users do not tire of the software and can find new ways to become more proficient at making video games..

But most importantly, tools also need to consider the participation issue and with it, shift their attention to the larger gaming community. Here "wide walls" signify the capacity of a tool to allow for a variety of creations—in this case, a wide variety of games. Effective game-making tools must allow their users to create a variety of game genres, be it platform games, first-person shooter games, RPGs (role-playing games), strategy games, and trivia games, to name a few. Likewise, "large windows" provide opportunities to connect with others to join gaming communities that revolve around same interests. Many communities now are connected to game design tools, including Kodu, Scratch, GameStar Mechanic, Spolder, and Game Salad. Some of these are specific to video games while others are more open-ended and allow for multiple designs besides games. These communities of game designers is a key component, from the early classrooms where kids designed their individual games to the massive online communities where games are some of the most popular designs shared. Gaining access to a wide and appreciative community means that players have the opportunity to leverage that community as an extension of the tool itself, with meaningful feedback serving to help fledgling designers gain a foothold into what works in game design, while more experienced designers can grow in proficiency and create increasingly intricate games.

From Old to New Clubhouses in Connected Gaming

If tools can provide access to new communities and communities can function as effective extensions of such tools, then we also need to address who is participating and who can participate in these communities. Gaming (Jenkins & Castell, 1998), but also coding communities (Margolis & Fisher, 2002), have a long history for not engaging girls and the reasons are multiple: on one hand, there is the lack of interest, lack of experience, and lack of skill from females, while on the other hand there is the persistent stereotyping of women in these same three areas, which is then compounded by a lack of female player roles and the prevalence of violence in games. This larger issue of gender differences is not germane to gaming alone—it is one that has plagued programming and STEM in the learning sciences at large. And yet, despite these persistent issues, constructionist gaming approaches have been seen as a possible remedy for addressing the gender divide so present in the gaming culture at large. An early study of game making revealed no significant gender differences in learning programming and disbanded with conventional wisdom at the time believed to be true: girls could be interested in programming and be interested in gaming, if they were just given the opportunity to make their own (Kafai, 1995). The success of girls in constructionist gaming became the launch pad for a whole series of tool developments (such as Storytelling Alice) and research initiatives to use game design to broaden girls' participation in computing.

While there was much success with game making to bring girls into the so-called clubhouses of computing and gaming, it also revealed a problematic aspect: why did girls have to design games in order to become gamers and more tech-savvy? This issue received little attention, even from the feminist side who mightily and justifiably lamented about the reification of stereotypes in girls making games (Jenson & deCastell 2007). The challenge we are faced with is to no longer simply question how to open the doors of existing technology and gaming clubhouses but how to build new clubhouses that envision different applications and activities in computing and gaming. The most prominent example here is the work by Leah Buechley who re-designed the Arduino board into the LilyPad Arduino for making electronic textiles. She found, indeed, new communities or clubhouses of coding could be created with such redesigns that are functionally equivalent in their technical complexity but application-wise result in the construction of different artifacts (Hill and Buechley, 2011). A possible equivalent in building new clubhouses for gaming could be to focus on the relationship between stories and games and conceiving of the game making process as a matter of crafting pathways rather than simply responding to stimuli (Westecott, 2012).

We of course have only touched upon the surface in imagining what connected gaming could look like and how it can begin to address these issues of access and participation. When the field of serious gaming started, attention nearly inordinately focused on proving the effectiveness of instructionist gaming (Clark, 2007) and "researching learning in popular gaming cultures, designing learning environments based on those principles, and reconceptualizing educational practice for an interactive age" (p. 51, Squire, 2007). Constructionist gaming really was not part of either discussion in building the field of serious gaming. But if we want to realize the larger potential of serious gaming, we need embrace a larger agenda that recognizes that opening access and participation in serious games is not solely a matter of making better games for the end user but allowing these end users themselves to make the games they would like to see and play. Ultimately, connected gaming's goal is to promote environments good for learning, and it is here where constructionist approaches join instructionist efforts. This is the case for "connected gaming", an approach that doesn't draw boundaries between players and designers as participants of digital media culture but rather sees them as complimentary to each other as already Papert envisioned: "if one does belong to a culture in which video games are important, transforming oneself from a consumer to a producer of games may well be an even more powerful way for some children to find importance in what they are doing" (p. iii, 1995).

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