Videogames and Complexity Theory: Learning through Game Play

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Abstract

The premise of this paper is that video games create rich and complex contexts for learning (Gee, 2007). Traditional understanding of learning separates complex tasks into simpler parts that can be learned with the amount of information reduced to manageable levels. However, this process of learning separates the known task from the context and separates the performer of the task from the intent of the task. Complex learning theory suggests that connecting the context, task and learner are critical to the human learning process (Barab & Plucker, 2002; Davis & Sumara, 2006). In this paper we examine how video games, examined from a complexity thinking framework, enable us to understand learning as a complex and emergent process, an ongoing fluid relationship between personal knowing and collective knowledge as the learner/player observes and acts in the observed world. Learning in video games becomes a process of information-action coupling (Chow et al., 2007; Davis & Broadhead, 2007; Renshaw, Davids, Shuttleworth, & Chow, 2008) where players' capacity to understand game play, to act effectively and to handle complex learning is enabled through interaction in the game, discussion with other players, and prior understandings from similar video games.

Author Keywords

Videogames; complexity; game play; learning

Introduction

The rich virtual worlds of videogames create powerful contexts for learning. In game worlds, as discussed by Shaffer, Halverson, Squire, and Gee (2004), "learners can understand complex concepts without losing the connection between abstract ideas and the real problems they can be used to solve" (p. 5). Games are most powerful – and most complex – when they are "personally meaningful, experiential, social, and epistemological all at the same time" (Shaffer et al., 2004, p.3). In this paper we will suggest how complexity theory provides a framework that enables us to understand learning as a complex and emergent process, an ongoing fluid relationship between personal knowing and collective knowledge as a person/videogame player observes and acts in the observed world. Learning skills in games becomes a process of 'perception-action coupling' within a self-organizing system of learners focused on the same intent (Chow, et al., 2007; Davis & Broadhead, 2007). As Barab et. Al (1999) note from a ecological perspective, this perception-action coupling occurs when players' capacity to understand game play (what they perceive) and their capacity to act effectively in the context is enabled through interaction in the game, discussion with other players engaged in the game, and prior understandings from other similar video games. Perception-action coupling refers to the person-in-situation creating an agent–environment system, not of an individual, or of an environment alone. As learners adapt to the perceived world in a self-organizing process, they develop a better relational connection to the perceived world, their task goals, and the actions and goals of others.

Traditional methods of learning implies decomposing tasks to manage information loads on learners, resulting in skills and knowledge being practiced and taught outside of the context of their application: the known being separated from the knower. In video games the known and the knower are inseparable, the actions of the player interact with the game-play environment creating an information-action coupling. This coupling becomes the knowledge of how to play the game as the player learns patterns and actions that lead to achieving the task of the game. As Gee (2007), as well as complexity theorists (Barab & Plucker, 2002; Davis & Sumara, 2006), refer to the notion of affordance that captures the idea of information-action coupling where objects and events of the virtual world are simultaneously coupled to the individual's avatar's behavior enabling learning and engagement in the problems of the task at hand (Gibson, 1979).

Complexity theory focuses on adaptive, self-organizing systems where learning emerges from experiences that trigger physical and behavioural transformations in learners. Video game players who play the same game become agents of a complex system of 'gamers' engaged in game-play where 'play' derives its meaning within an environment that is interactive, dynamic and flowing, where there are infinite possibilities, a to-and-fro process, and limits provided by the structure or rules of the game (Hopper, Sanford & Clarke, 2009). Enjoyment and commitment are implied conditions of game-play as the challenge of the game engrosses the players. The generative power of such a complex system is its inherent instability, which represents the capacity for players to learn as agents within the system. Stability, embodied by learners as boredom, loss of interest, and elimination of 'playfulness' (Clarke, 2008), is the death knell of a dynamic system. Gee (2003) further suggests that videogames develop system thinking through a series of progressively designed sub-games offering affordances to the players, encouraging players to think about relationships, not isolated events, facts, and skills. Players see each game as a distinctive semiotic system enabling (and discouraging) certain kinds oof actions and interactions, supporting complex understandings as they develop the perception-action couplings. Bringing a complexity sensibility to learning demands that we attend to the following features of a complex system of learners:

1) **Diversity** among the learners that provides generative possibilities (not liabilities) for game play if appreciated by the players;

2) **Emergent decentralized control** that allows for local understandings and interpretations to be generated in context;

3) **Liberating constraints** or "guidelines and limitations for the activity" that "serve as common experiences and a basis for a common vocabulary while allowing learners to adapt their activities to their specific interests and understandings" (Davis, 2004, p. 169);

4) **Redundancy** or a degree of commonality, essential for communication and shared understanding that constitutes game-play between players as they interact around each other's learning;

5) **Learning is 'distributed',** recognizing that concepts like cognition or skill are not just confined to the brain, but are distributed over the body, other people and the tools at hand (Putnam & Borko, 2000). In learning game skills, the learner needs to take an active part in interpreting (reading), using (applying) and generating (producing) information within a simplified game context that has the same features of play as the full featured game.

Jack's insights on his video game-play with peers

The following story, told by an adolescent video-gamer, provides the context for discussion in this paper about how video games are examples of adaptive self-regulating complexity systems modeling rapid perception-action coupling for players. As such, the story provides the significant reference points for the paper as elements of complexity theory are explored. Jack recounts a story about his Halo 2 party, where he recreates a networked game of *Halo 2* in order to play synchronously with some of his friends. *Halo 2* has been one of the most popular science fiction first-person shooter video games in the past few years, with a strong multi-player component, recently replaced by its equally popular sequel *Halo 3*.

One member of the research team joined Jack in watching two other players engage with Halo 2. The researcher asked Jack where he watched on the screen when he is playing with other videogame players. The conversations moved to where he played *Halo 2* and whether he played it live. He said that he didn't have an Xbox live hook-up, but proceeded to relate the story of how he played a six-person networked game of Halo at his house…

"I had a Halo 2 party to celebrate Halo 3 coming out… at my house and there was…(thinking) …4 Xboxes. One in my room, one in the kids' room, one in the bathroom and one in the living room. And we all had teams that played against each other. It was cool. I have a TV, there's a TV in the living room, we have an extra TV; there's my 24", the living room 32", the spare's a 27", and someone else brought over their 24". And we'd just play. The bathroom was the funnest spot though. We're like sitting in the bathtub and we're like, "Yeah" (he pretends to be cramped up forwards, holding a controller in his hands). Then every now and then we'd switch teams and switch locations so we could all play with each other. So the team that was in the bathroom would move into my room. There were 4 people per team. So we'd say, we'll trade you Aaron if you give us Brad. So he'd get out of the bathroom, and so literally they'd switch around. So we'd have different combinations for different games. Yeah, it was pretty cool.

I want 'Live' but it seems like a pain because I would lose the signal…because of the computer hook up in my house.

When my friends and I decide who we want to play with it's not about skill or about friendship, it's just that we need players and we figure that if we are going to play with someone, it's better *that they are better than us because they can help us get better in the game if we're playing with someone with more skill than us.*

Another comment I'll make is that Grand Theft Auto isn't a bad game … everyone's like, drunks, shooters, Mafia, bad things, shooting cops, body parts everywhere…It is like that for the storyline, but me and my brother and a couple of our friends and a guy from Australia came together, we played our own game types on line, like The Border and Chicken Train – so, you can kill cops and whatever, or you can drive into a train with a motorcycle (laughter from the group). There's just a bunch of game types, we made up games within the rules of Grand Theft Auto and changed the game."

Learning Principles

Gee (2003), known for his work from a semiotic perspective on how video games enable powerful learning, missing in traditional school structures, outlines significant learning principles developed in videogames. This paper will connect these learning principles to the complexity theory features identified above, noting how video games develop possibilities for video game players to become (1) empowered learners, (2) effective problem solvers, and (3) successful gamers with in-depth understanding. These areas enable video gamers to be able to generate a depth of conceptual understandings necessary to engage more fully with a complex world.

Empowered Learners

Through many specific video game playing examples, Gee (2007) makes a compelling case for **enabling and empowering learners**, so that they can take ownership of their own learning. Five specific learning principles cluster around the notion of learner empowerment:

1. **affordances** – the player has skills to engage in the environment
2. **co-design** – players design games by the actions they take and decisions they make; some games can 'write' the worlds they play in
3. **customization** – choice of how to play the game and how playing style affects the outcome
4. **identity** – connection between identity and activity engaged in; player takes on a role and learns based on goals and purpose of identity
5. **manipulation** – 'smart tools' used in intricate ways to extend areas of effectiveness; game character has 'in-built' knowledge, knows things like how to jump, where, when, and why to engage in actions (Gee, 2003)

These learning principles support complexity theory's features of **diversity** and **emergent decentralized control**, and are demonstrated in Jack's story of adapting structures and rules in a self-organizing manner. Gee (2003) refers to customizing videogames, gameplay, and gameplay environments, so that players can shape and adapt the virtual worlds they play in; this customizing is evident in the story Jack told. Jack was able to create a gameplay space for himself and several friends using existing resources, reshaping his home into a multi-player quasi on-line environment. Because of existing knowledge of on-line gaming environments, Jack was able to envision an opportunity for himself and his friends, drawing on the physical and knowledge resources provided by the group to set up and play *Halo 2*.

Diversity

Diversity among the learners provides generative possibilities that create rich opportunities for game play. Once they began playing, Jack and his friends also drew on the diverse expertise of the players, using "different combinations for different games", switching around the teams to best utilize each others' expertise. Demonstrating Gee's learning principle of manipulation, Jack and his friends modified both the play space and the play itself – playing *Halo 2* in the bathtub created both physical and cognitive differences in the way it had been played in past situations! Although Jack did not have access to a 'live' connection in which to play an on-line game, he reshaped the environment. Recognizing that in order to learn more about the game and about playing the game he needs to engage with players of more ability and experience, Jack selects his on-line players accordingly – "we figure that if we're going to play with someone, it's better that they are better than us because they can help us get better in the game if we're playing with someone with more skill than us". By challenging himself in this way, he can create more exciting and enjoyable experiences for himself and his friends.

This increased learning also allowed Jack to manipulate games to better suit his own purposes. For example, Jack reshaped *Grand Theft Auto* into a game he enjoyed playing more with his friends, one that connected his past experiences of playing "chicken" in the neighbourhood with childhood companions to his current experiences of playing videogames with friends locally and around the world.

Emergent decentralized control

Jack was able to adapt his home environment to play a version of on-line *Halo 2* because local understandings and interpretations (of Jack and his friends) were generated in the context available to them. The emergent decentralized control allowed for local understandings and interpretations to be generated in the specific context, therefore, the game outcomes cannot be completely predetermined by the game developers, but come to be increasingly controlled by the players themselves. Rather than giving up on their desire to play together, Jack and his friends collectively created a version that was possible in the circumstances, not one that was envisioned by the game designers. Their abilities were enhanced by previous experiences with players (often on-line players who were otherwise unknown to them) who were better than they were at the game, providing them with expertise that they later were able to recognize and use in new situations. These capabilities are referred to by Gee as 'affordances', where the players have skills to engage in the environment, perhaps not in the way imagined by game creators, but in ways that are possible in the particular context, with the particular skills and knowledge of the particular players. They are then able to 'co-design' a play space with the original game designers, a space that only develops with local as well as general knowledge of the game rules and design. Jack and his friends also co-designed a hybrid *Grand Theft Auto* game, drawing on previous experiences and knowledge to reshape the very popular (and controversial) game into one that provided more pleasure for these particular players. They were able to recognize the positive qualities of the game, as a non-linear and very complex immersive world, reshape some of the aspects of the game that were not appealing to them, and use the structure to create a game for themselves.

Effective problem-solvers

Videogames are filled with **problem-solving** opportunities for players, where they find environments that engage them in immersive worlds and stimulate their thinking. Gee (2007) has developed seven learning principles that support problem-solving opportunities for videogame players:

1. well-ordered problems – early problems in games are designed to lead players to form good guesses about how to proceed when they face harder problems in the game
2. pleasantly frustrating – challenge is on the outer edge of learners' comfort zone, but within their 'regime of competence', and feels possible and do-able
3. cycles of expertise – expertise is formed through repeated cycles of learners practicing skills until they are almost automatic; then these skills are challenged, which allow further learning; game levels expose players to new challenges
4. information "on demand" and "just in time" – games give verbal and visual information "just in time" when the player needs it, or "on demand" when the player requests it
5. fish tanks – games create a simplified eco-system that show critical variables and their interactions, preparing the learner for the complex system of the full game
6. sandboxes – games create safe 'play spaces', minimizing the cost of risk and danger, allowing the game to restart from the last place saved
7. skills as strategies – addresses the paradox involving skills, that people do not like practicing skills out of context, but need skills to get good at what they are trying to learn; to practice, players need to know how skills translate into strategies, and know the game.

Complexity theory's features of **redundancy** and **liberating constraints** support Gee's principles related to problem solving, and are seen in many features of Jack's *Halo 2* story. These features enhance communication and connection between players' prior and current experiences, and between different players' knowledge and experiences. Redundancy, or a degree of commonality, is essential for communication that constitutes gameplay between players as they interact around each others' learning, sharing vocabulary and technical terms, strategies, game design knowledge, and play experience. The liberating constraints create a flexible structure that guide the play experience while not limiting changes that might be possible through problem-solving abilities. The liberating constraints, in the form of guidelines and limitations of the game, provide common experiences and vocabulary, while also enabling players to adapt to specific contexts and abilities. Jack and his friends were quickly able to create a common vision of their gameplay space, and between them had the ability to create such a space – Jack provided the location and the gear, and the group provided the expertise and the will to create such a play space. The commonly known structure of *Halo 2* provided constraints within which to work as they set up the environment, yet allowed for a new type of play and play space to emerge.

Redundancy
Jack provides examples of redundancy or commonality as he animatedly relates the story of his *Halo 2* night. All of the players came together to play a game they all knew and loved to play; they brought to the evening background knowledge of the game which allowed Jack's initial idea to develop into a common vision and space. As the players scouted out available resources (TVs, rooms, hookups) they verbally and non-verbally communicated their intentions, guided by Jack's initial idea. They used a variety of situations and players' expertise to further develop their skills, sharing ideas with each other and learning from previous online players they had hooked up with. Gee refers to their developing and shared skills as 'cycles of expertise', formed through repeated cycles of learners practicing skills until nearly automatic, then having their skills challenged so that they can continue to learn. Game levels expose players to new challenges referred to as 'fish tanks', 'where games create a simplified version that shows critical variables and their interactions, and prepare players for the complex system of the full game. Jack and his friends originally played *Halo 2* from the beginning, where the game structure skillfully and seamlessly introduced the game space, the rules, characters, and challenges to neophyte players who drew on experiences of playing earlier versions of the game and other games in the same genre. The players themselves were able to create their own version of an existing game that they all knew well, in this instance *Grand Theft Auto*, to create simplified versions of a very complex videogame that they enjoyed playing as a short-term diversion.

Liberating Constraints
Videogames offer players well-ordered problems that enable them to progress through a game as they develop skills and understanding of the context. These 'enabling constraints' (Davis & Sumara, 2005) highlight the importance of creating tasks broadly enough to enable exploration but focused enough for specific outcomes to be generated by the rules of the game. Boundaries, or rules, to a game are designed in such a way to allow for a range of possible outcomes. As Gee (2003) describes, the games are designed to lead players to form good guesses about how to proceed when they face more challenging problems at later stages of the game. The challenges are increasingly but pleasantly frustrating, encouraging players to progress from the outer edge of their comfort zone or 'regime of competence', drawing them into increasingly challenging situations and problems. Jack's *Halo 2* evening exemplified not only increasing competence in problem-solving within the game, but also in modifying and shaping gameplay environments. There was no signal in order for them to play an on-line game, so they collectively pooled resources, manipulated the spaces and the equipment in order to simulate a more professional on-line space. They came together for a common purpose, that is, to play *Halo 2*, to learn more from each other, to improve their skills, and to have fun.

Successful gamers with in-depth understanding

As Jack's Halo 2 party plan emerged, his **understanding** of the game and the environment was evident, revealing a depth of physical, emotional, and cognitive engagement in his retelling of the evening's events. Jack's ability to shape a quasi on-line environment emerged from his previous experiences with playing Halo 2 and other first person shooter games, as well as his ability to reshape and create new experiences from existing games. Through Jack's story we can recognize the learning principles identified by Gee (2003) that focus on understanding:

1. **system thinking** – games encourage players to think about relationships, not isolated events, facts, and skills; players see each game and each genre of game as a distinctive semiotic system affording (or discouraging) certain sorts of actions and interactions

2. **meaning as action image** – players think through experiences they have had, and run possible scenarios of how to solve a problem in their imaginations

In this way learning is distributed, located not only in an individual's brain but located elsewhere in one's body, and in connections with others and with the tools available, enables us to more broadly understand how learning happens through videogame play. The learning described by Jack in his *Halo 2* party scenario provides examples of how physical, emotional, and cognitive learning occurred for him and for his friends as he developed spaces to play and to create. Learning is described in terms of complexity theory as having many locations, learning changes as the community of learners and the tools change. This notion of complexity for learning and understanding connects to the learning principles described by Gee (2003) in relation to how learners adapt to different environments and situations that are afforded by videogames.

Different play spaces use the body, the tools, and the expertise of individuals in the best ways possible given existing circumstances. For example, playing *Halo 2* in the bathtub changes the way the game is played, making it a different experience than playing on the living room couch. Body position can determine physical capabilities and connects to emotional and cognitive responses. These factors relate to the way a game is played, and possibly to the outcome of the game. Games encourage players to engage in 'system thinking', recognizing relationships between skills, information, and events. Knowledge of the game structure of Grand Theft Auto enabled Jack and his friends to change it into a game of 'chicken', producing a new game-play experience for them. They were able to make connections between their prior knowledge and experiences to understand what the game would allow them to do and to adapt existing game systems to shape this new experience. They could understand the game as a distinctive system that allowed not only for interactions intended by the game designers, but also for new interactions that they could imagine for themselves.

In his *Halo 2* home party, Jack thought through his knowledge of how on-line games worked and other situations he had seen. Considering his available resources, he overcame the problem of not having a live connection, creating meaning as an action image (Gee, 2003). Jack was actively interpreting, applying, and producing new ideas that he drew from other game-play situations he knew and understood.

Conclusion

The sense of video-gamers being empowered to solve complex problems allows them to experience the feeling of in-depth understanding, to learn how to take risks and solve challenging problems. Essentially, good videogames create highly complex environments that create new worlds for video-gamers, immersive worlds that intrigue, engage, and enable sophisticated learning. Good videogames draw players into very challenging learning experiences and motivate them to continue, often for long periods of time. Good videogames also create interesting and important problems that players need to solve in order to continue their involvement in worlds in which they love to virtually live; in sum, good videogames are fun. As noted by Davis and Sumara (2006), complexity theory focuses on adaptive, self-organizing systems where learning emerges from transformation in the learner triggered by the experience. Understanding videogames as adaptive, self-organizing systems enables us to make better sense of complex global worlds, both 'real' and 'virtual'. Videogames encourage self-organizing systems which encourage players to focus on connections and relationships (Gee, 2007) rather than decontextualized skills and facts, thus encouraging meaningful learning and understanding that empowers learners to adapt their perceptions and resulting actions in the video game world. Learning is understood as an emergent process, an ongoing renegotiation of the perceived boundary between personal knowing, collective knowledge and the environment as a person observes, acts and engages in the perceived world. In is no wonder that such a rich experience of learning is so attractive to so many adolescent and young adult players. If we can understand learning in this way, surely we can enhance the way we institutionalize learning in society.

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