Harnessing Computer Games in Education

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ABSTRACT

Besides the ability of making learning more interesting, educators and researchers have been exploring other pedagogical potentials of computer games. How to employ games for constructivist learning and teaching has become an attention in the field of education and game design in recent years. This article gives an introduction to game-based learning. On top of discussing games' intrinsic educational traits from the motivational, cognitive and socio-cultural perspectives, we also review two recent foci of game-based learning. The first one is "education in games" which is an approach for adopting existing commercial games for educational use. The second is "games in education" in which the games are designed specifically with underlying pedagogy for some curricula.

Keywords: please provid

INTRODUCTION

The pervasive spread of computer games has made a significant impact on different aspects in our society (Newman, 2004). Sustaining spontaneous players' engagement (Gee, 2003) and exploiting proactive players' communities (Prensky, 2006) are substantive features of today's games. This emerging attention has been one of the main reasons for the increasing number of educators and researchers worldwide (e.g., Chiu et al., 2005; Halverson, 2005; Shaffer 2006; Squire, 2005; Egenfeldt-Nielsen, 2007) to treat game-based learning as a topic of serious research in the field of education.

There has been a great promotion of shift in education from a didactic model of instruction to a constructivist model that emphasizes more an active learner role. Learning is believed to be at its best when it is goal-oriented, contextual, interesting, challenging, and interactive (Quinn, 2005).

On the other hand, some researchers (e.g., Egenfeldt-Nielsen, 2002; Gee, 2003) also believe that the computer game world is totally learner-centered, and is therefore a possible venue for realizing a constructivist learning paradigm. This article aims at discussing the intrinsic educational traits of computer games from different perspectives and reviewing some recent research on game-based learning strategies.

Intrinsic Educational Traits of Computer Games

Since the early 1980s, employing human game-playing motives to facilitate learning has been a significant research focus of game-based learning (Squire, 2003; Egenfeldt-Nielsen, 2007). More recently, some researchers (e.g., Gee, 2003; 2005; Squire, 2005; Prensky, 2006; Shaffer, 2006) have also argued that games' underlying cognitive, social, and cultural features can offer various "educative" opportunities for learners. In the following, we discuss games' intrinsic traits that promote learning in a constructivist fashion from the *motivational*, *cognitive* and *socio-cultural* perspectives.

Motivational Perspective

Research evidence (e.g., Bisson & Luncknер, 1996; Cordova & Lepper, 1996) has shown that fun and enjoyment are important in the process of learning as learners can be more relaxed, motivated and willing to learn. Based empirically on a series of surveys, observations and interviews with game-players, Malone (1980) gave his intrinsic motivation theory, which asserts that *challenge*, *fantasy*, *control*, *curiosity*, *cooperation*, *recognition* and *competition* are the most significant elements that make game-playing fun and engaging, and sustain players' continual motives. Malone advocated that schools should try to integrate game elements into curricula so as to arouse students' intrinsic learning motives.

Bowman (1982) tied his study on game-playing and learning with the psychological conception of *flow*—a state of optimal experience, whereby a person is so engaged in an activity that self-consciousness disappears, and time becomes distorted (Csikzentmihalyi & Larson, 1980). In the flow state, individuals work on complex, goal-directed task(s) not for external rewards, but for the exhilaration of doing. Bowman believed that learning with games is an effective means to bring students to the flow state of learning.

Computer games are fun, pleasurable, challenging and rewarding (Prensky, 2001). From both empirical and theoretical points of view, learners will be more motivated and engaged in educational activities if these activities take place in a form of game-playing.

Cognitive Perspective

The traditional school curricula are often fragmented into small and unconnected pieces (Papert, 1993). The original intention is for making learning easier, but this usually ends up with depriving the rationale behind the knowledge itself, creating unrealistic learning contexts, and making learning boring. Learning should be an active process based upon concrete experience (Piaget, 1964). Without chunking or turning contents into a series of split-screens, a well-designed game can do well in presenting near real-life contexts for individuals to acquire knowledge and skills unintentionally rather than deliberately (Gee, 2003). This is *situated learning*—a learning paradigm that Lave and Wenger (1991) have been advocating.

When discussing the educational potentials of computer games, we should classify the games into *mini-games* or *complex-games* (Prensky, 2006). In general, playing mini-games takes around several minutes to an hour to complete. Usually, these games contain simple challenges and contents, with neither ethical dilemma nor human players' interactions. On the contrary, complex games require players' dozens of hours (or even more) of concentrated attention to master with. Players are demanded to acquire new and multiple skills, and communicate (or collaborate) with other players inside and outside the games (Gee, 2003; Quinn, 2006). Most tasks therein are generative and open-ended with neither prescribed strategies nor solutions. Players have to analyze the perceived information and contexts in complex games proactively. They also have to apply their existing knowledge and skills to formulate strategies, make decisions, and then examine results.

Complex games offer the prospect of user-defined learning environments (Halverson, 2005) in which individuals can tryout and get feedbacks on their assumptions and strategies. This is a new cognitive way for learners to acquire knowledge and skills in a constructivist fashion (Bisson & Luncknер, 1996; Shaffer, Squire, Halverson, & Gee, 2005).

Socio-Cultural Perspective

How to educate learners is not seen as how to build representations in each of their heads, but how to engage them in social practices (Lave & Wenger, 1991). Knowledge itself arises from social needs, fulfills social functions, and is tied inherently with cultural conditions (Cole, 1996). Thus, learning is not just a process of mastering facts, or even doing complex tasks, but rather, participating in socio-cultural practices. This requires learners to develop their own identity in relation to others.

Most of today's game-playing activities are situated socially and culturally (Gee, 2003), entwining practice, participation, community and identity. The gamer generation prefers human competitors and/or collaborators rather than purely artificial intelligence (AI) (Prensky, 2001). Players meet online and form teams to discuss challenges, complete quests, and solve puzzles. Moreover, nearly every prevalent game does not simply appear alone as a game itself, but exists logically as a *game system* (Prensky, 2006). In each of these systems, besides a complex game and a synchronous chat platform therein, it also consists of players' self-initiated components, such as online discussion forums, fans' sites, and blogs, and so forth. All of these components enable and encourage individuals to share, discuss, evaluate and apply the community knowledge co-constructed by the community members.

In didactic schooling approaches, learning takes place through teaching and testing (Gee, 2005) and students can gain standardized learning experiences only (Halverson, 2005). Compared to those traditional approaches, game-based learning can create a more social and cultural world that helps individuals learn by integrating thinking and social interactions (Shaffer et al., 2005). The whole learning process does not need to be face-to-face or take place in schools.

COMPUTER GAME-BASED LEARNING

Learning and teaching with computer games has been discussed since the early 1980s (e.g., Malone, 1980; Bowman, 1982),

but regrettably most of today's educational games are still lacking in quality (Egenfeldt-Nielsen, 2007, p. 19). According to Squire's (2003) review of game-based learning, the most popular genre of learning games adopted in schools has been drill-and-practice. Without taking either the versatile advantages of games' intrinsic educational traits or today's computing technologies, drill-and-practice games have just been promoting rote memorization (Card, 1995). These games offer no opportunities for learners to interact, create, and share what they create with other learners. In recent years, however, some researchers in this field (e.g., Chiu et al., 2005; Halverson, 2005; Squire, 2005; Shaffer 2006) have been trying to tackle this problem. In the following, we discuss and give some examples of representative work on two recent foci of game-based learning. The first one is "education in games", that is, the educational use of existing commercial games. The second is "games in education", that is, designing learning games with underlying pedagogy for specific curricula.

Education in Games

Squire (2005) studied how to integrate a prevalent commercial game, **Civilization III**[1], into U.S. high-school classrooms. Civilization III allows players to lead a civilization from 4000 B.C. to the present, in which players compete for political, scientific, military, cultural, and economic victories. In this game, each player has to seek out geographical resources, manage economics, plan the growth of his/her own civilization, and engage in diplomacy with other players competitively and collaboratively. Squire introduced playing **Civilization III** as a new cognitive approach for motivating high-school students to understand some "used to be boring" topics in World History.

Gee (2003) also advocated exploring the possibilities of adopting commercial games in education. Commercial game designers try their best to make their games hard but fun, time-spending but enjoyable, complex but learnable; otherwise, nobody will keep on playing their games. Thus, many of bestselling commercial games (e.g., Full Spectrum Warrior[2]) are already "state of the art" learning games, and actually most of these games are based on the principle of *distributed authentic professionalism* (Gee, 2005).

Distributed authentic professionalism refers to the distribution of authentic professional expertise between NPCs (non-player characters) and players' avatars while players are engaged in specific activities, values, and ways of seeing during game-playing. Professional knowledge and practices are embodied through the interactions between NPCs and players. Thus, players can gain first-hand experiences on how members of these professions think, behave, and solve problems. The whole cognitive process is both situated socially and culturally.

Games in Education

Shaffer (2006) gave a more detailed account of Gee's (2005) idea of distributed authentic professionalism. Members of a profession have an *epistemic frame*—a particular way of thinking and working, that is, a grammar of a particular culture. In other words, epistemic frames are the conventions of participation that learners become internalized and acculturated. Thus, developing individuals to be members of a particular professional is a matter of equipping them with a right epistemic frame. The development should be grounded with meaningful activities that align with the

cored skills, habits, and understandings of that professionalism. To accomplish this, Shaffer advocated immersing learners to participate in, what he has been calling, *epistemic games*.

Instead of adopting existing commercial games, in recent years, Shaffer together with his research team have developed a number of epistemic games. These games are designed for learners to participate in simulations of various professional communities that they might someday inhabit. The communities include, for example, biomechanical engineers in **Digital Zoo**[3], ecological thinkers in **Urban Science**[4]**,** as well as journalists in **Journalism.Net**[5], and so forth.

Folklore-based learning (Lee, Lee & Lau, 2006) is another games-in-education example. Folklore-based learning is a game-based situated learning paradigm in which learning activities are in an interactive adventure highlighted by problem-solving tasks situated in a folklore-based story plot. This paradigm aims as not only empowering learners to learn in an authentic situation, but also offering interesting story episodes as a motivating agent for less initiated learners. As prototype work, Lee et al. developed a folklore-based learning game, namely, **Tong Pak Fu and Chou Heung**[6], on the subject of probability. This game is composed of several game-playing stages. In each stage, learners are presented a problem, from sample space construction in the first stage, to simple probability, and to conditional probability, and eventually the "Monty Hall Problem" (Fowler, 1996) in the last stage. Throughout the game-playing process, learners have to experience and tackle the problems within predefined learning contexts.

Pedagogy for Game-Based Learning

Only leaving learners to float amidst rich experiences but without teachers' guidance in the process of game-based learning does not work (Gee, 2005). Learners often have difficulties in making connections between the scenarios happening in a learning game and the corresponding real-world system that the game intends to represent (Clegg, 1991). Moreover, games make assumptions and more or less contain biases (Thiagarajan, 1998); even a high-fidelity simulation game still cannot represent reality.

We believe a learning game by itself may unlikely facilitate effective learning, unless opportunities of initial enablement, reflection and generalization of abstraction are embedded therein. Game-based learning is necessary to be concatenated with pedagogy, and thus we proposed *VISOLE—Virtual Interactive Student-Oriented Learning Environment* (Chiu et al., 2005; Jong et al., 2006).

VISOLE is a three-phase constructivist pedagogical approach to empower game-based learning, which encompasses the creation of a near-real-life online interactive world modeled upon a set of multi-disciplinary domains. In **Phase 1 (*Multi-disciplinary Scaffolding*)**, teachers act as cognitive coaches to activate students' learning motive and assist students to gain some high-level abstract knowledge upon a selected multi-disciplinary framework. In this phase, students are equipped with "just enough" knowledge, and given some possible knowledge pointers. Thus, in the next learning phase they will be able to acquire the necessitated knowledge in a learner-centered fashion.

Phase 2 (*Game-based Learning*) deploys an online multi-player interactive game portraying a virtual world. The scenarios therein become the dominant

motivator driving students to go on to pursue the inter-related understandings of the multi-disciplinary abstractions encountered in Phase 1. In the game, each student participates as a character who takes part in shaping the development of the virtual world for a period of time. All missions, tasks and problems in the game are generative and open-ended with neither prescribed strategies nor solutions. Since every single action can affect the whole virtual world, students have to take into account the overall effects associated with their strategies and decisions to others. "Living" in this virtual world, students have to not only acquire the subject-specific knowledge in an interdisciplinary fashion, but also the generic skills of problem analysis, strategy composition and decision making, and so forth.

Phase 3 (*Reflection and Debriefing*) interleaves with the activities in phase 2. After each game-playing session, students are required to write in their reflective journals to internalize their learning experiences. On the other hand, teachers monitor the progress of students' development of the virtual world at the backend. They look for and try to act on debriefable moments to "lift" students out of particular situations in the game. These debriefing activities aim to help students to transform their game-playing experiences into learning experiences, so that they can reflect and generalize their gained knowledge and skills. Respectively during and at the end of this phase, teachers extract problematic and critical scenarios arisen in the virtual world, and then conduct just-in-time and summative case studies with their students by deploying some face-to-face debriefing classes.

FARMTASIA[7] (Luk et al., 2006) is an educational game developed which is based on the pedagogical paradigm of VISOLE, involving the subject areas of geography (natural environment and hazards as well as environmental problems), biology, economics (including government and production system) and technology, while the "virtual world" consists of interacting farming systems. Empirical research (Jong et al., 2007) has shown that VISOLE could empower students (K-10) to acquire multi-disciplinary knowledge, and on the other hand offer opportunities for enhancing their generic skills for managing problems.

CONCLUSION AND DISCUSSION

In the past, game-based learning used to be interpreted as a means for "sugaring" didactic schooling (Aylett, 2005). The premise was that learning is not fun but game-playing is fun, and the introduction of game elements should be able to make learning more interesting. In recent years, a number of educators, researchers (e.g., Gee, 2003; 2005; Chiu et al., 2005; Shaffer, 2005; Squire, 2005) and practitioners from the commercial sectors (e.g., Quinn; 2005; Prensky, 2006) have been exploring various educational potentials of computer games, and opportunities for adopting game-based learning into the contemporary education systems.

In this article, we discuss the intrinsic educational features of today's computer games that favor constructivist learning. We also review some recent research interests on the educational use of commercial games, such as Gee's initiative (2003; 2005), and Squire's work (2005). Educators and researchers in this approach focus on investigating the possibilities of a direct transformation of *entertainment* to *edutainment*. On the other hand, we go through some "games in education" instances, such as Shaffer's epistemic games

(2006), Lee et al.'s (2006) folklore-based learning paradigm, and Chiu et al.'s (2005) VISOLE pedagogy. The games involved in these instances are designed specifically for some curricula with an underlying pedagogy. Educators and researchers in this approach focus mainly on adopting commercial game's "educative" (such as motivational, cognitive and socio-cultural) traits in developing "educational" games.

We have no intention to argue that all learning should be via game-playing. However, we believe that game-based learning could be an integral part of our education systems allowing a variety of contemporary pedagogical approaches to co-exist and interplay. Some researchers argued that today's educational environment is still not flexible enough to accommodate game-based learning in place (e.g., Squire, 2005), and the real integration of computer games into formal schooling has not yet been explored systematically (e.g., Halverson, 2005). Besides discussing how to design and develop the best computer games for the educational use, another urging issue is the actual adoption, implementation, and evaluation of game-based learning within school and institution settings.

REFERENCES

Aylett, R. (2005). And they both lived happily ever after? Digital stories and learning. In: G. Dettori, T. Giannetti, A. Paiva, & A. Vaz (Eds.), *Technology-mediated narrative environments for learning*. Amsterdam: Sense Publishers.

Bisson, C., & Lunckner, J. (1996). Fun in learning: The pedagogical role of fun in adventure education. *Journal of Experimental Education, 9*(2), 109-110.

Bowman, R. (1982). A Pac-Man theory of motivation. Tactical implications for classroom instruction. *Educational Technology, 22*(9), 14-17

Card, O. (1995*). What are computers doing at school*. Windows Sources.

Chiu, L., Luk, T., Lee, J., Lee, F., Leung, Y., & Chau, K. (2005). Virtual interactive student-oriented learning environment (VISOLE): A new Web-based learning paradigm. *Proceedings of the 9th Global Chinese Conference on Computers in Education,* (pp. 834-837). Hawaii, USA.

Clegg, A. (1991). Games and simulations in social studies education. In: J. Shaver (Ed.), *Handbook of research on social studies teaching and learning* (pp. 523-528). New York, NY: Macmillan.

Cordova, D., & Lepper, M. (1996). Intrinsic motivation and the process of learning: Beneficial effects of contextualization, personalization, and choice. *Journal of Educational Psychology, 88,* 715-730.

Csikszentmihalyi, M., & Larson, R. (1980). Intrinsic rewards in school crime. In: M. Verble (Ed.), *Dealing in discipline*. Omaha, NE: University of Mid-America.

Egenfeldt-Nielsen, S. (2002). *Thoughts on learning in games and designing educational computer games*. www.Game-research.com.

Egenfeldt-Nielsen, S. (2007). *Educational potential of computer games*. New York, NY: Continuum.

Fowler, G. (1996). *Monty Hall (let's make a deal) problem*. Retrieved February 23, 2005 from

http://www.nadn.navy.mil/MathDept/courses/pre97/sm230/MONTYHAL.HTM

Gee, J. (2003). *What video games have to teach us about learning and literacy.* New York, NY: Palgrave Macmillan.

Gee, J. (2005). *What would be a state of the art instructional video game look like?*. Retrieved July 28, 2007 from http://www.innovateonline.info/index.php?view=article&id=80

Halverson, R. (2005). What can K-12 school leaders learn from video games and gaming?. *Innovate, 1*(6). Retrieved July 28, 2007 from http://www.innovateonline.info/index.php?view=article&id=81

Jong, M., Shang, J., Lee, F., & Lee, J. (2006). A new vision for empowering learning and teaching with IT: The VISOLE approach. *Proceedings of the Hong Kong International IT in Education Conference 2006: Capacity building for learning through IT,* (pp. 18-25). Hong Kong, China.

Jong, M., Shang, J., Lee, F., & Lee, J. (2007). *An exploratory study on VISOLE – A new game-based constructivist online learning paradigm*. Paper presented at America Educational Research Association Annual Convention 2007 (AERA). Chicago, IL.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge, UK: Cambridge University Press.

Lee, J., Lee, F., Lau, T. (2006). Folklore-based learning on the Web—pedagogy, case study, and evaluation. *Journal of Educational Computing Research, 34*(1), 1-27.

Luk, E., Wong, M., Cheung, K., Lee, F., & Lee, J. (2006). Design and implementation of FARMTASIA: A game designed for the VISOLE teaching style. In Z. Pan, R. Aylett, H. Diener, X. Jin, S. Gobel, & L. Li (Eds.), *Proceedings of the 1st International Conference of Edutainment 2006: Technologies for E-Learning and Digital Entertainment,* (pp. 566-571). Hangzhou, China.

Malone, T. (1980). *What makes things fun to learn? A study of intrinsically motivating computer games.* Palo Alto, CA: Xerox.

Newman. J. (2004). *Videogames*. London: Routledge.

Papert, S. (1993). *The children's machine: Rethinking school in the age of the computers*. New York, NY: Basis Books.

Piaget, J. (1964). Development and learning. *Journal of Research in Science Teaching, 2,* 176-186.

Prensky, M. (2001). *Digital game-based learning.* New York, NY: McGraw Hill.

Prensky, M. (2006). *Don't bother me mom – I'm learning*. St. Paul, MN: Paragon House.

Quinn, C. (2005). *Engaging learning*. CA: Pfeiffer.

Shaffer, D. (2006). *How computer games helps children to learn*. New York, NY: Palgrave Macmillan.

Shaffer, D., Squire, K., Halverson, R., & Gee, J. (2005). *Phi Delta Kappan, 87*(2), 104-111.

Squire, K. (2003). Video games in education. *International Journal of Intelligent Games & Simulation, 2*(1).

Squire, K. (2005). Changing the game: What happens when video games enter the classroom?. *Innovate, 1*(6). Retrieved July 28, 2007 from http://www.innovateonline.info/index.php?view=article&id=82

Thiagarajan, S. (1998). The myths and realities of simulations in performance technology. *Educational Technology,* 35-41.

ENDNOTES

1 http://www.civ3.com/ (Retrieved on July 28, 2007)

2 http://www.fullspectrumwarrior.com/ (Retrieved on July 28, 2007)

3 http://epistemicgames.org/eg/?cat=15 (Retrieved on July 30, 2007)

4 http://epistemicgames.org/eg/?cat=14 (Retrieved on July 30, 2007)

5 http://epistemicgames.org/eg/?category_name=journalism-game (Retrieved on July 30, 2007)

[6] http://www.cse.cuhk.edu.hk/~mhp/ (Retrieved on July 30, 2007)

[7] http://www.farmtasia.com/ (Retrieved on 30 July, 2007)

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