EDUCATIONAL USE OF COMPUTER GAMES: WHERE WE ARE, AND WHAT'S NEXT

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1. INTRODUCTION

The activities that games are associated with are "play" (Games & Squire, 2011). Piaget (1964, 1970) regarded curiosity as the best driving force for learning. He advocated that keeping learners curious by engaging them in play-like activities is the best approach to education, and thus games are an important avenue toward learning. Papert (1980, 1993), a proponent of Piaget, observed that gaming can foster students' deep learning. He highlighted that, in gaming, students are more conscious of the objects that surround them. When students interact with what goes on around them in a game, they begin to understand "what things are and how things work," and thus become more willing to spend time and effort on it. Shulman and Keislar (1966) realized that gaming can help students develop their skills of learning. Students will feel better about what they learn in games, and try to apply the acquired knowledge and skills in the future.

The early educational use of computer games, which treated computer games as "a content transmission platform" as opposed to "a tool to think with," was less contributive to education (Provenzo, 1991). Along with the advancement of technology and the advocacy of student-centredness in education, the contemporary educational use of computer games has become more connected with learning models that promote learning as experience (Dede, 2011). It is believed that "good" computer games have the potential to provide learners with authentic and engaging experiences that enhance their learning and retention (Cannon-Bowers, 2010; Tobias & Fletcher, 2011).

This chapter aims at providing readers with a contextual view on educational use of games, particularly, computer games. In Section 2, before elaborating on the intrinsic educational traits of computer games and some early instances of computer game-based learning, we will start from discussing games "in general," and some examples of "non-computer" games for learning. In Section 3, we will introduce two recent initiatives of educational use of computer games, namely, "education in games" and "games in education," and discuss a number of representative instances in each initiative. In Section 4, we will delineate the challenges of computer game-based learning that we are facing currently, and discuss the areas which are worth investing further research effort. Section 5 is a conclusion of the chapter.

2. GAMES AND EDUCATION

Heinich et al. (1982) described "game" as an activity in which players follow prescribed rules for attaining some challenging goals. They highlighted that the rules in games are different from those in real life and thus make gaming fantastic and entertaining. Although Heinich et al.'s argument is applicable to some non-computer games (e.g., *Tic-tac-toe*, *Bingo*, *Chess*, etc.) and also some computer games (e.g., *Pan Man*, *Tetris*, *Mario Brothers*, etc.), it has yet to be comprehensive enough to cover all games in the past and today. For example, *Rift Raft* (Leigh & Kinder, 1999), a non-computer role-play game, replicates authentic happenings arising when people are engaging in negotiation. *Journalism.net* (Shaffer, 2006), a computer simulation game, lets people gain first-hand experience of how journalists think and behave in real life.

Giving a definition to "game" is a difficult and complex task (Livingstone, 1972; Sandford & Williamson, 2005). Different games, no matter non-computer-based or computer-based, can have a very different "technical" design therein. Some games have scoring, but some do not. Some games have real win and lose stages, but some do not. Some games are in a purely competitive manner, but some require players to work collaboratively. Some games focus on providing players with fantasy experience, but some advocate for offering players authentic experience. Instead of proposing a universal definition of "game," Mayer (2011) generalized four key structural characteristics of games that make a game a "game;" they are (1) *rule-based*, (2) *responsive*, (3) *challenging*, and (4) *cumulative*. Rules in games enable players to play. Responses of games make players feel their actions are reacted. Challenges in games pose goals for players to achieve. Cumulative features of games aggregate players' past gaming successes.

2.1. Learning through Gaming

The earliest utilization of games for learning purposes can be traced back to the use of war games in the 1600s for improving the strategic planning of armies and navies (Gibbs, 1974; Gredler, 2004; Lederman, 1992; Peters & Vissers, 2004; Wolfe & Crookall, 1998). Parallel to the spread of the ideas of "learning through playing" to education by a number of constructivist learning theorists in the early 1960s (e.g., Bruner, 1960; Piaget, 1964; Shulman & Keislar, 1966), there have been more educators, school teachers, and vocational trainers endeavouring to infuse games (non-computer ones) into classroom teaching or skill-based training (e.g., Barton, 1970; Bredemeier & Greenblat, 1981; Heinich et al., 1982; Leigh & Kinder, 1999; Smith, 1971; Thiagarajan & Stolovitch, 1978; van Ments, 1999). Cruickshank and Telfer (1980) categorized those non-computer games for education into *non-simulation games* and *simulation games*.

Non-simulation games (Cruickshank & Telfer, 1980) are those in which players solve problems such as spelling and mathematics by making use of principles of a subject or discipline. For example, in *Acrostics*, students have to find words of equal length, the number of words being the same as the number of letters in each word. Afterward, the words are arranged so that each can be read vertically and horizontally. *Scrabble*, *Sudoku*,

etc. are other well-known examples of non-simulation games and still popular to date. Prensky (2001, 2006), however, argued that non-simulation games are only attractive to pre-schoolers or lower-grade students, but not higher-grade students—particularly the youngsters of *digital native*—"the new 'native speakers' of today's digital language of computers, computer games, and the Internet" (p.28).

Simulation games (Cruickshank & Telfer, 1980), another category of non-computer games for education, aim at providing students with insights into the processes or events from the real world that are simulated. Games in this category usually involve students in making decisions and communicating with one another in a role-playing manner. For example, in *Prisoner's Dilemma* (Barton, 1970), two players are placed in the role of captured criminals presented singly with the opportunity to confess to the crime and thereby promised a shortened sentence for themselves and a longer one for the accomplice. If only one confesses, he wins a shorter sentence. If both confess, they both receive longer sentences. This game lets players experience and understand phenomena of competition and cooperation.

Simulation games are considered suitable for simulating interaction between humans, as well as the functions performed by humans under various social circumstances (Leigh & Kinder, 1999; van Ments & Hearnden, 1985; van Ments, 1999). This kind of games are, however, less capable for simulating scientific models and systems (composed of mathematical variables and equations) in some disciplines such as Geography, Physics, Economics, etc. On top of that, simulation games are usually subjected to a limit on the number of participants, allowing only a few students to participate simultaneously (Heinich et al., 1982).

2.2. Computer Game-based Learning (GBL)

Apart from the introduction of non-computer games to education, the discussion of harnessing computer games for learning and teaching has been launched since the widespread popularity of *Pac-Man* in the early 1980s (Squire, 2003), and catalyzed by video-game consoles and personal computers entering households (Games & Squire, 2010). Undoubtedly, the games discussed in most of today's computer game-based learning research are different from the ones that were used in the last few decades. The differences do not lie solely on the technical enhancement brought by the advancement of technology, but also their underpinning educational paradigm, shifting from behaviourism to constructivism.

2.2.1. Computer Games for Behaviourist Learning

The behaviourist conception in education advocates a human's mind can be treated as a black box (Skinner, 1938). The inner-workings inside this black box need not be uncovered. The study of learning should focus only on observable events (i.e., stimuli and responses). Through practice students will learn the correct response to a stimulus; learning can be imposed by conditioning and reinforcement. Behaviourism was the dominating learning paradigm adopted in the design of "educational games" (or

"edutainment") when computer games were introduced initially to education (Egenfeldt-Nielsen, 2007; Gredler, 1996; Squire, 2003). These games are composed of fantasy themes wrapped around drill-and-practice activities (Games & Squire, 2010), and thus so-called "drill-and-practice games."

Drill-and-practice games usually consist of a clear reward structure for pushing students' learning forward, but have weak or even no relationship between learning content and game context (Egenfeldt-Nielsen, 2007). For example, in *Math Blaster!*, students have to shoot down the right answer to a mathematics question shown on the screen. On each success, their balloon will move towards a needle. A student who can pop his/her balloon eventually will win the game. Tying closely in-game rewards to in-game actions, drill-and-practice games, to a certain extent, can provide attractive frameworks for learning activities, and foster pleasant and relaxed classroom atmosphere which is helpful especially for low academic achieving students who unlike conventional types of learning and teaching (Heinich, 1996). However, it has been criticized that the movement design of these games is usually too fast and leaves no room for students to think and reflect; students may just play with their spontaneous responses or trial-and-error strategies (see Wong, 2003).

"A game that is fun to play but does not help students acquire the intended knowledge, skills, or attitudes has little value for instructional purposes" (Tobias & Fletcher, 2011, p. 535). Kirriemuir and McFarlane (2004) argued that the "sugared" and "parrot-like" activities in drill-and-practice games should not occupy a significant part of a school day or during students' independent study time. Gee (2011) criticized further that decontextualized drill-and-practice experience in these games can never facilitate human to learn deeply and meaningfully.

2.2.2. Computer Games for Constructivist Learning

Drawing from Dewey's (1938, 1958) and Piaget's (1964, 1970) notions of constructivist play, some educators and game researchers in the early days tried to develop their computer games to facilitate constructivist learning. For example, in the early 1970s, three teachers in Minnesota created *Oregon Trail*, a computer game for helping students understand the historical complexities of American pioneers' lives during nineteenth century migrations (cited in Games & Squire, 2011). Students in this game can interact with a virtual world by typing text-based commands, engaging in activities like hunting for food, and protecting caravan members from disease, poisonous animals, and other possible dangers. In the early 1980s, Papert (1980) developed *Microworlds*, a computer game encompassing self-contained interactive worlds for modeling real-life systems. The worlds therein are able to react to students' commands in accordance with, for example, Newton's model of the laws of motion. This game let students explore phenomena that are difficult to access either in the real world or school settings due to physical constraints or disciplinary prerequisites. The publication of *M.U.L.E (Multiple Use Labor Element)* in 1983 was another milestone of constructivist use of computer games in education (cited in Games & Squire, 2011). This game involves mechanics of strategic resource management, allowing one to four players to contest resources as prospectors on

a fictional planet. Players can choose various traits and skills for their colonists, tying them to various strategies. Players should not only compete but also work cooperatively in order to survive in the planet.

In the recent years, along with the advancement of computers, multimedia, and the Internet (such as sophisticated computer simulations, 3D user-interfaces, dynamic synchronous players' interactions, etc.), as well as the pervasive promotion of student-centric pedagogy, the discussion of drill-and-practice games has become in the minority in the domain. On the other hand, the focus of educational use of computer games has been place significantly on the issue of how to harness their motivational, cognitive, and social abilities to facilitate constructivist learning. The following will discuss the traits of todays' computer games that support constructivist learning, in terms of *promoting learners' motivation*, *offering learners situated cognitive experiences*, as well as *exploiting learning communities*. For writing convenience, unless otherwise specified, hereafter the terms *game(s)*, *gaming*, and *game-based learning (GBL)* denote "computer game(s)," "computer gaming," and "computer game-based learning" respectively.

Promoting learners' motivation

Fun and enjoyment are essential elements in the process of learning as students can be more relaxed and motivated to learn (Bisson & Luncker, 1996; Cordova & Lepper, 1996). Gamers always undergo hard but engaging, challenging but pleasurable, and risk-taking but rewarding experiences in gaming (Prensky, 2001). All these are the experiences of fun and enjoyment.

There have been a number of GBL studies focusing on investigating what, why, and how gaming can make students more motivated during the process of learning. For example, based on a series of surveys, observations and interviews with gamers, Malone (1980, 1981) put forward a motivation theory, which asserts that *challenge*, *fantasy*, *control*, *curiosity*, *cooperation*, *recognition*, and *competition* are the most significant elements that make gaming fun and engaging, and sustain gamers' continual motives. Malone advocated that schools should try to integrate similar gaming elements into education so as to arouse students' intrinsic motives in learning. Bowman (1982) tied his study on learning through gaming with Csikszentmihalyi's (1975, 1990) psychological conception of "flow." Flow is a state of experience of "intense concentration and enjoyment." Under the flow state, a person will engage in a complex, goal-directed challenge not for external rewards, but simply for the exhilaration of dealing with the challenge. Bowman observed that learning through gaming is a spontaneous way to bring students to the flow state of learning.

Although the studies of Malone (1980, 1981) and Bowman (1982) were done a few decades ago, recent empirical evidence (e.g., Cordova & Lepper, 1996; Mayer, et al., 2002; DeLisi & Wolford, 2002) still accords with their assertions. From both theoretical and empirical points of view, it is expected that students will be more motivated to participate in educational activities if these activities take place in a form of gaming.

Offering learners situated cognitive experiences

Jonassen and Howland (2003, p.8) argued the "greatest intellectual sin" that educators have committed is to oversimplify knowledge and skills taught at school in order to make them more "transmissible" to students. The learning contents at school are often fragmented into small and unconnected pieces (Papert, 1993). The original intention is for making learning easier, but this usually ends up neglecting the rationale behind the knowledge itself, creating unrealistic learning contexts, and rendering the whole learning process boring. Without chunking or turning learning content into a series of "split-screens," with the advancement of multimedia and simulation technology, today's games do well in presenting near real-life contexts for students to acquire knowledge and skills in a more spontaneous manner (Shaffer, 2006). This sort of learning experience coincides with Lave and Wenger's (1991) conception of "situated learning."

Gee (2003, 2005, 2007) believed that gaming is a new cognitive way for learners to acquire knowledge and skills in a constructivist fashion. Today's games offer the prospect of user-defined learning environments (Halverson, 2005) in which individuals can try out and get feedback on their assumptions and strategies. Most gaming tasks are generative and open-ended without prescribed gaming strategies. Gamers engaged in gaming cannot be passive (Antonacci & Modaress, 2008). They need to interact (compete, cooperate, or collaborate) with other human gamers or NPCs (non-player characters) inside games (Mason & Moutahir, 2006). They also have to analyze and evaluate the perceived information and context in games proactively, and to create new gaming strategies based on their knowledge and skills.

Exploiting learning communities

Scardamalia and Bereiter (1993, 1996, 2003) observed that, focusing on individual students' abilities and learning, schools inhibit rather than support collaborative knowledge building. In fact, knowledge itself arises from social needs, fulfills social functions, and is tied inherently with cultural conditions (Cole, 1996; Collins, Brown & Newman, 1989). In other words, how to educate students is not seen as how to build representations in each of their heads, but how to engage them in socio-cultural activities (Lave & Wenger, 1991). Learning is not just a process of mastering facts, or even conducting complex tasks, but rather, participating in socio-cultural practices. This requires learners to develop their own identity in relation to others.

Today's games are considered as "cultural artefacts situated within socio-technical system" (Games & Squire, 2011, p. 28) in which entwine practice, participation, community, and identity (Wenger, 1998). The gamer generation prefers human competitors and/or collaborators rather than purely AI (artificial intelligence) (Prensky, 2001). Gamers meet online and form teams to discuss challenges, complete quests, and solve puzzles in games. 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 the game concatenating with a built-in real-time chat console, it also entails gamers' self-initiated components, such as online discussion forums, fan sites, blogs, etc. All these components enable and encourage individuals to share, discuss, evaluate, and apply the collective knowledge co-constructed by gamers/learner communities (Antonacci & Modaress, 2008).

3. CONTEMPORARY INITIATIVES OF GBL

In this section, we will discuss a number of recent instances of constructivist educational use of games in the domain. We categorize these instances into two initiatives, namely, (1) *education in games* (i.e., adopting existing *recreational games*[1] from the commercial market for educational use, and (2) *games in education* (i.e., developing *educational games*[2] that are designed with specific educational purposes).

3.1. Education in Games

In Richter and Livingstone's (2011) recent publication, they discussed a person, who works in a major global Internet firm, credits his experience in running a large guild in *World of Warcraft* as an important factor in his subsequent success securing a senior management position his company. Gee (2003, 2005, 2007), an active education-in-game proponent, realizes that nowadays recreational games in the commercial market are not only extending the creative boundaries of interactive media, but also suggesting powerful models of next-generation interactive learning environments. He observes that many bestselling recreational games are already state-of-the-art learning games since they are hard but fun, time-consuming but enjoyable, and complex but "learnable." In his recent publication (Gee, 2011), he went on arguing that—

> *In my view, no one has made such [an educational] game that is as good as, say, the commercial game Portal, which allows players to experience and use principles like the conservation of momentum …… no one, in my view, has made such [an educational] game that is as good as the commercial game Civilization, a game that lets players experience and use principles about historical change and the clash of civilizations …… (p. 231)*

Besides Gee (2003, 2005, 2007, 2011), there have been a number of education-in-game proponents (e.g., Cameron, 2008; Hub, 2008; Johnson, 2005; Marquis, 2008; Prensky, 2001, 2006; Salen, 2007, 2008) advocating for the potential of recreational games for promoting youngsters' high-order thinking skills (Anderson et al., 2001) and/or so-called "twenty-first century literacy" (Jenkins et al., 2006). However, it has been argued that this advocacy is just a kind of "theoretical argument," without empirical evidence (DiPietro et al., 2007; Mayer, 2011, Mishra & Foster, 2007). Instead of staying in theoretical discussions, some education-in-game initiators have conducted empirical

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[1] Researchers and commentators sometimes use the terms "mainstream games" (e.g., Kirriemuir & McFarlane, 2004; Sandford & Williamson, 2005), "off-the-shelf games" (e.g., Prensky, 2001, 2006; Squire, 2003), and "serious games" (e.g., Gee, 2003, 2005; Mishra & Foster, 2007) to mean *recreational games*.

[2] In contrast to recreational games which are designed originally for entertainment purposes, the term *educational game(s)* refers to the game(s) that are designed deliberately for education purposes. Some researchers and commentators (e.g., Kirriemuir & McFarlane, 2004; Gee, 2003, 2005) use the term "learning games" to mean *educational games*.

studies on adopting recreational games in educational settings (e.g., Adam, 1998, Betz, 1995; Kemp & Livingstone, 2006; Rankin & Shute, 2010; Squire, 2004, 2005).

In fact, the educational use of recreational games coming to larger public attention was in 1989—the time that *SimCity* was first released. This game is a city-building game where players play the role of a city mayor, planning and executing changes to the infrastructure of a city, and managing the consequences of their design decisions (see Games & Squire, 2011). *SimCity* was a commercial hit upon its release. In education, this game and its newer versions released in 1990s were a common interest for many educators who had been exploring the use of computer simulations for learning and teaching in the areas such as government and urban planning in that decade (Kirremuir & McFarlane, 2004). For example, Adam (1998) adopted *SimCity* in a university-level introductory Urban Geography course for his own students to acquire urban planning concepts in a self-directed manner. Adam realized that the game could not only approximate to near real-world conditions and phenomena of designing and building a city, but also demonstrate the potentially successful or disastrous consequences of complex decision making in urban planning. Prior to the adoption, Adam analyzed *SimCity*, and set up a number of learning objectives related to urban planning that he expected the students could achieve after playing the game. Further, he conducted a learning experiment to verify quantitatively whether the gaming would yield the expected learning outcomes. The research results were positive, in terms of the students' knowledge acquisition and their perceptions of "learning through gaming." These findings also accorded with those in a similar study conducted by Betz (1995) who had adopted *SimCity* in teaching his college-level Architecture course.

Civilization (first released in 1991) is another popular recreational game which has aroused the interest of educators and GBL researchers. *Civilization* is a turn-based game. In each turn players must choose from a multitude of possible actions ranging from studying the map of the world surrounding their tribe, to creating new cities, to exploring new technologies or making war against other civilizations. The game provides opportunities for players to learn how to micromanage the resources that they own (such as gold, food, building materials, etc.), and the consequences of policy decisions (such as raising or lowing taxes, changing the form of government, etc.). In the recent versions of *Civilization*, the ability to customize game scenarios and move students from players to designers of scenarios (creating their own versions of historical simulations) has been compelling more educators to bring this game to education (see Games & Squire, 2011). As an empirical study, Squire (2004, 2005) integrated *Civilization* into a US high-school classroom for teaching of a formal school curriculum of world-history. In his study, Squire concluded the students could develop more understanding and interest in historical knowledge to a certain extent; on the other hand, he found that it was difficult to align the "educative" content in the game with what was required in the curriculum concerned.

The empirical adoptions of *SimCity* and *Civilization* in educational settings have led to further discussions of educational potential of some technically-similar recreational games such as *Sim Earth* for learning of ecology, *Zoo Tycoon* for learning of zoology, etc. (see Prensky, 2006). Kemp and Livingstone's work (2006) is another representative

education-in-game instance. They utilized *Second Life*, an MMORPG (massively multiplayer online role-playing game), as an online "socio-cultural" LMS (learning management system) to facilitate learning and teaching activities (lectures, tutorials, discussions, student presentations, etc.) in university courses. More recently, Rankin and Shute (2010) have also re-purposed *EverQuest II*, another MMORPG to promote learning in the context of second language acquisition. In their experimental study, they observed that the in-game social interactions between native speakers and non-native speakers could provide greater learning engagement among the participants. In contrast to traditional classroom teaching, this game-based approach facilitated an enhancement of the non-native speakers' second language vocabulary acquisition and reading comprehension.

Notwithstanding some positive education-in-game instances discussed above, there have been critiques on this initiative. For example, the authenticity and accuracy of the "educative" contents in recreational games have been arousing concern from educators, teachers, and also learners (Kirriemuir & McFarlane, 2004; Klabbers, 2006). For example, *SimCity* distorts the mayor's authority in public planning, simplifies the historical vitality of race and ethnicities in the evaluation of cities, and overestimates the appeal of public transportation to most Americans (Kolson, 1996). A large percentage of players doubt the historical accuracy of *Civilization* (Squire, 2004, 2005). Moreover, designed originally for entertainment purpose rather than education purpose, recreational games are difficult to be adopted in normal curriculum teaching by school teachers (McFarlane et al., 2002; Halverson, 2005; Rice, 2007). Without a GBL expert (like Squire [2004, 2005] in his study) in schools, it is unrealistic to ask a teacher (who is usually a non-gamer) to identify what and how a particular recreational game is relevant to a particular part of a subject curriculum, and design according learning activities based on the game, and then implement the activities in his/her teaching practice.

3.2. Games in Education

Instead of adopting existing recreational games from the commercial market, game-in-education researchers design and implement their educational games based upon explicit pedagogical paradigms or/and articulated with specific learning contents. The following are some selected instances upon this initiative.

Emergent narrative is the underlying pedagogy of Aylett's (2005) "narrative games." This paradigm suggests learning through role-playing in an improvised, rather than scripted digital story. The plot of the story in a narrative game emerges from the interactions between players' avatar and NPCs therein. *FearNot!* (Aylett, Figueiredo, Louchart, Dias & Paiva, 2006), which is an example of narrative games, was developed specifically for an anti-bullying campaign for child education. Children in this game act as counselors to give advice to victims (the NPCs in the game) who are being bullied. Their advice will influence the proceedings about the victims in the next gaming episode. The children can then observe the consequence of the actions taken by the victims in accordance with their prior advice.

Progressive inquiry (Muukkonen, Hakkarainen & Lakkala, 1999) is the underlying learning paradigm of Jong et al.'s (2010) *Learning Villages (LV)*—a CSCL (computer supported collaborative learning) game. *LV* operates in a form of MMORPG, in which each student can design his/her own avatar to participate collaboratively in "two-tier" inquiry in a progressive manner. In the "virtual world" of *LV*, each "village" represents an inquiry issue. A student can initiate an issue for inquiry by creating a village (he/she becomes the "chieftain" of this village). Other students can enter this village and build "houses" to elaborate on their views, arguments or questions with respect to the issue (and hence they become the "villagers" of the village). Further, both chieftain and villagers can construct different types of "roads" to interconnect the houses for delineating their in-between relationships. This is the first-tier inquiry, so-called "village-level discussion." Apart from that, every house in the village is "enterable," functioning as an individual forum to facilitate discussion of a particular view, argument or question raised at the village-level. This is the second-tier inquiry, so called "house-level discussion." When the number of quality houses reaches a certain amount, the village will be upgraded by their learning facilitator (usually their teacher). Benefits brought to the students by the upgrade include higher social status conferment for enjoying extra privileges in the virtual world, such as pet keeping, mini-game playing, etc. The two-tier inquiry approach in *LV* visualizes, in the process of learning, students' collective views, arguments and questions, as well as their in-between relationships in the form of mind map (at the village level), while the discussion of a particular view, argument, or question can be recorded in and recalled from a single access point systemically (at the house level). *LV* has been adopted in facilitating cross-region inter-school collaborative inquiry learning projects among Hong Kong students and other students from China, Singapore, and USA, in the areas of personal, social and humanity studies.

Distributed authentic professionalism, which refers to the distribution of authentic professional expertise between NPCs and players' avatars, is the underlying educational belief of Shaffer's (2006) "epistemic games." Shaffer realized that members of a profession have an epistemic frame—a particular way of thinking and working. From the learning perspective, epistemic frames are the conventions of participation to which learners become internalized and acculturated. Thus, developing people to be members of a particular profession is a matter of equipping them with a right epistemic frame. To accomplish this, Shaffer and his team developed a number of epistemic games as extra-curriculum programmes for middle-school-aged students (outside school hours) to participate in simulations of various professional communities (which they might someday inhabit). These communities include, for example, biomechanical engineers in *Digital Zoo*, and ecological thinkers in *Urban Science*. More recently, a number of epistemic games have been adopted as a testing tool for assessing students' higher order thinking (see Shaffer & Gee, 2010).

Based on the theoretical foundations of *Situated learning* (Lave & Wenger, 1991), *scaffolding* (Vygotsky, 1978), and *reflection* (Dewey, 1958), Jong et al.'s (2010a) proposed "VISOLE" (Virtual Interactive Student-Oriented Learning Environment)—a teacher-facilitated pedagogical approach to GBL. It encompasses the creation of a near real-life online interactive world modeled upon a set of multi-disciplinary domains, in

which each student plays a role in this "virtual world" and shapes its development. It aims at providing students with opportunities not only to acquire subject knowledge in a multi-disciplinary fashion, but also sharpen their higher-order thinking skills. VISOLE is composed of three pedagogical phases. In Phase 1 *(Multi-disciplinary Scaffolding)*, a teacher assists students in gaining some preliminary high-level abstract knowledge (as their prior knowledge to the next learning phase) based upon a selected multi-disciplinary framework. Phase 2 *(Game-based Situated Learning)* and Phase 3 *(Reflection and Debriefing)* take place in an interlacing fashion. Phase 2 deploys an online multi-player interactive game portraying a virtual world in which the students play a role to shape the development of this world by accomplishing generative and open-ended tasks. In order to finish the tasks, they have to acquire new knowledge and skills on their own not only from the designated learning resources but also the Internet. In Phase 3, the students are required to write a piece of gaming journal to reflect on their learning experience in the virtual world after each bout of gaming. Also, in this phase the teacher will monitor the students' development of the virtual world at the backend, and extract scenarios arising in the game to debrief the students through case studies. *Farmtasia* (Cheung et al., 2008), the first game for enabling Phase 2 of VISOLE, was developed based on a multi-disciplinary topic, Agriculture, in the formal senior secondary Geography curriculum in Hong Kong. It is a bout-based game, deploying interacting farming systems of cultivation, horticulture, and pasturage. Teachers can review students' performance and extract gaming scenarios for conducting case studies through a dedicated teacher console. In this game, each student acts as a farm manager to run a farm and competes for financial gain and reputation. They have to optimize their investment and operational strategies in order to yield both quality and abundant farm products for profit making. Moreover, they have to be conscious of their practice in sustainable development and environmental protection which determine their reputation in the virtual world. Jong et al. (2010b), in an evaluation study of VISOLE with 254 Grade 10 students from 16 secondary schools, obtained positive results in terms of the students' advancement in the knowledge and higher-order thinking skills concerned.

Upon the game-in-education initiative, so-called "serious games" (or "non-entertainment-based learning games" in Gee's [2011] terms) has become another focus in the recent years. Serious games, which refer to the games implemented with the state-of-art gaming technologies, are designed for instruction purpose (either education or training) rather than entertainment purpose (Cannon-Bowers, 2010; Sawyer et al., 2008), consisting of meaningful and near-real life contextualization to engage learners for achieving specific "serious" instructional goals (Games & Squire, 2011). These games can not only provide learners with relatively safe and non-threatening environments to conduct more "risk-taking" tasks in the course of learning, but also protect them from the severe consequences of their mistakes made therein (Garris, Ahlers & Driskell, 2002). *River City* (Dede et al., 2008) and *Guardian Angel* (Andrews et al., 2010) are two recent examples of serious games. *River City* encompasses a 3D multi-player "virtual world," placing learners in the role of scientists to research an outbreak of diseases in a virtual town. In this game, they have to make observations, collect data, as well as conduct analysis for investigating the cause of the diseases. *Guardian Angel* is for mental health education, particularly in the area of addiction recovery and prevention. In this game,

each player plays the role of an angel to "watch over and guide" a NPC (a virtual patient) in a full year of sobriety. This game aims at equipping players with RP (relapse prevention) craving-management techniques, including drink refusal, identification of high-risk situations, lifestyle-balancing, cognitive restructuring, assertiveness training, cognitive restructuring, and stimulus control.

4. GBL: NEXT CHALLENGES

Tobias and Fletcher (2011) argued that—

> *It is difficult to be specific about the place of games in schools of the future. At one extreme are traditional schools pursuing the required curriculum and ignoring games entirely. At the other extreme are experimental schools where games essentially are the curriculum …… Games may gradually be infused into the curriculum. The pace of such infusion is likely to depend on research findings demonstrating that games improve student learning …* (p. 539-541)

Although most of today's youngsters regard games as a "must-have" item at school (Kamil & Taitague, 2011), we are indeed hard to predict the extent of the use of games in education in the coming decades. Mayer (2011, p. 281) argued that, "many strong claims are made for the educational value of computer games, but there is little strong empirical evidence to back up those claims." Regardless a considerable number of education-in-game and game-in-education instances in the current domain (as discussed in Section 3), the learning effectiveness of GBL has still been a large concern from the public (see DiPietro et al., 2007; Hannifin & Vermillion, 2008; Mishra & Foster, 2007; O'Neil & Perez, 2008).

In Tobias, Fletcher, Dai, and Wind's (2011) recent literature review of the GBL studies carried out between 1992 and 2009, they observed that the evidence regarding learning from games has been less robust than what educators and other educational stakeholder are expecting. Most of those studies were summative evaluations, each looking at if there is a significant difference between the advocating GBL approach and an ordinary educational practice. Dede (2011) argued the scholarly focus of GBL should expand beyond the narrow concern of whether a recreational or educational game can yield so called "learning outcomes" at "a significance level of 0.05." The future of GBL depends on the researchers' ability in the field to show how games can be applied in education successfully (Cannon-Bowers, 2010). The following four aspects, we believe, need further attention in the GBL domain. We urge more research effort should be put into these aspects in the coming years.

For "whom" GBL works

Learning is quite diverse in its manifestations among humans (Bransford et al., 2005). There are always different kinds of learners in an educational setting (Biggs & Moore, 1993). So is in a GBL environment. There has been no consensus on the categories of "players" in gaming. Gee (2011) divided game-players in general into *not-at-all gamers*,

causal gamers, and *regular gamers*. Bartle (2003) classified MMORPG players into *killers*, *socializers*, *achievers*, and *explorers*. However, it should be noted that the "players" described by Gee and Bartle are "gamers," not equivalent exactly to "players in GBL." Gamers play (or do not play) games in accordance with their own personal preference and choices (e.g., interest, experiences, as well as what games, when, where, etc.). On the other hand, "players in GBL" are actually learners in ordinary educational settings. We should always remember that not every learner enthuses about gaming. Besides, not every game is appealing to learners even if they love gaming. Some non-gamer students (who are not interested in gaming) may see GBL is a sort of "unpleasant" homework which they are "subjected" to do it (Jong et al., 2010c). Some academic achieving students (who are examination-oriented) may realize participation in GBL is wasting their time and impeding them to get good results in school exams (Jong et al., 2011a). Some gamer-students (who possess rich experiences in gaming) may criticize that the games used in GBL at school are too boring, in comparing with the ones they are playing during their leisure time (Jong et al., 2011b).

We argue that, when one claims a particular GBL approach or a game is good (or effective or bad/ineffective, etc.) for learners, it is important for the one to specify clearly what kinds of learners whom are in his/her claim. Gee (2011) and Dede (2011) in their recent publications have also shared a similar view with us—

> *Showing that a game, a type of game, or games as a whole work or don't work for one category of gamer or learner does not show they work or don't work for other categories of gamers and learners …* (Gee, 2011, p. 225)

> *Educational research strongly suggests that individual learning is as diverse …yet theories of learning and philosophies about how to use interactive media for education tend to treat learning as an activity relatively invariant across people …* (Dede, 2011, p. 236)

In most of past evaluation studies of GBL approaches, in fact, there has been little discussion of categorizing different kinds of GBL learners and then studying in-depth the learner's GBL process in each category. We believe, however, this is crucial work for answering the "whom" question if a researcher want to conclude a particular GBL approach is contributive to education. In our previous study of VISOLE (as discussed in Section 3.2, see also Jong et al. [2010b]), we observed a number of the students' personal factors affecting their participation in the GBL process. These personal factors were *gaming interest*, *prior gaming experiences, emotions generated during gaming*, and *conceptions of learning*. These findings can provide some insights into the issue of how to categorize learners in a GBL setting.

Significance of meta-gaming in GBL

Most of today's GBL advocators (e.g., Barab et al., 2007; Gee, 2003, 2005, 2007; Jong et al., 2010a; Shaffer, 2006) argue games are good for education because they observe games are not just pieces of computer software, but "game systems" (as discussed in

Section 2.2.2, and see also Prensky, 2006) involving abundant in-game and off-game interactivities among players. In-game interactivities are apparent in many nowadays multi-player recreational and educational games in which players interact (compete or/and collaborate) with one another simultaneously. Off-game interactivities usually involve players' self-initiated social interactions, such as discussing and sharing gaming strategies and experiences, as well as learning how to modify ("mod") games through discussion forums, blogs, social networking systems, fan websites, etc. These players' interactivities are termed "meta-gaming" (Gee, 2011).

GBL, in today's context, is a combination of gaming and meta-gaming (Gee, 2003, 2005, 2007, 2011; Prensky, 2001, 2006). The learning outcomes of a particular GBL approach stem not only from gaming but also meta-gaming. The latter, however, has been receiving little attention in empirical research in the domain. We urge more research effort should be placed on investigating (1) *the significance of meta-gaming in the process of GBL*, (2) *the inner-workings between gaming and meta-gaming*, and (3) *how gaming and meta-gaming are articulated best for maximizing the effectiveness of GBL.*

Teachers' roles in GBL

The games in nowadays GBL instances are usually composed of near-real life simulations for providing learners with learning contexts as similar as those in the real world (Cannon-Bowers, 2010). Nevertheless, even high-fidelity simulations can never be exact reflections of the reality (Thiagarajan, 1992, 1998). On top of that, learners often have difficulties in making connections between the simulated situations in a game and the referring real-world systems (Clegg, 1991; Crookall, 1992). Although learners are sometimes requested to reflect on their own experience in the process of GBL, not everyone is able to do it well equally (Brandsford et al., 2005).

Despite the promotion of constructivist learning paradigms in GBL that emphasizes a more active student role, teachers are still the best at seeing when, what and why students are confronted with puzzles arising in the process of the learning, and scaffolding them to solve the puzzles constructivistly (Brush & Saye, 2002; Collins, Brown & Newman, 1991; Howard, 2002; Johnston & Cooper, 1997; Jonassen, 1998; Peters & Vissers, 2004). Regrettably, there has been little discussion of the significance of teachers and their specific roles in the process of GBL. Our proposal of VISOLE (a teacher-facilitated pedagogical approach to GBL, as discussed in Section 3.2) has been in the minority in the field.

VISOLE (Jong et al., 2010a) specifies a number of teacher scaffolding and debriefing tasks in GBL for helping students transform their gaming experience into learning experience. VISOLE, however, has yet to be "perfect." For example, in our empirical study (Jong et al., 2010b), we found that teachers' emotional support to students is indeed a very important element in the process of GBL, but we had not considered this aspect in the design of VISOLE. We believe, nevertheless, the pedagogical paradigm of VISOLE, and its empirical findings regarding teacher facilitation in GBL can shed light on the further discussion of teachers' roles in both education-in-game and game-in-education initiatives in the domain.

GBL works best in "what"

There has been literature (e.g., Bransford et al., 2005; Shulman, 1986) documenting no optimal pedagogical approach is effective across different subject areas. Dede (2011) also argued that—

> *" No learning medium is a technology like fire, where one only has to stand near to get a benefit from it …… the nature of the content and skills to be learned shape the type of instruction to use …(p. 237)*

Learning is an activity variant across different curricula. Similar to other constructivist learning approaches such as WebQuest (Dodge, 1995), Problem-based Learning (Barrows, 1996), and Project-based Learning (Krajcik & Blumenfeld, 2006), GBL does not work universally. Apart from students' personal factors and teachers' facilitation, the success of a GBL instance depends largely on whether the learning content concerned is suitable to be embedded in a game-based context. We realize that further research on what kinds of educational aims, objectives, topics, and subjects are delivered best through GBL is important.

5. CONCLUSION

In this chapter, we have discussed the educational use of games, starting from its early purpose of "sugaring the pill" (making learning more interesting) to its recent focus of facilitating constructivist learning in terms of games' abilities to sustain spontaneous players' engagement, offer players near real-life simulation-based experiences, and exploit proactive players' communities. We also categorize the contemporary constructivist GBL instances into two initiatives, *education in games* and *games in education*, as well as discuss a number of representative instances among each initiative.

Similar to other educational innovations (either technology-based or non-technology-based), GBL holds a number of promises for education. It is expected that educational use of games will continue to be prominent for the foreseeable future (Games & Squire, 2011; Kamil & Taitague, 2011). However, the proof for games as a tool for learning has yet to be deep so far (Gee, 2011; Mayer, 2011; Tobias & Fletcher, 2011); further research has to be done before we can provide the public with convincing evidence for supporting GBL. We realize a good research model for educational innovation is not only to answer "whether" an innovation works in general, but also understand how it works and explain why it works. Instead of proposing a full research agenda for GBL researchers (it is complicated work that absolutely needs collective effort in the field), we aim at adding some items into this agenda, or at least initiating a "dialogue" about some directions for evolving this agenda. We have suggested four areas which are worth investing additional research effort. They are (1) *for "whom" GBL works*, (2) *significance of meta-gaming in GBL*, (3) *teachers' roles in GBL*, as well as (4) *GBL works best in "what."* We believe gaining an in-depth understanding of each of these aspects will certainly provide new insights into the future development (both design and implementation) of games for educational use.

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