Chapter 11
VISOLE: A Constructivist Pedagogical Approach to Game-Based Learning

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ABSTRACT

VISOLE (Virtual Interactive Student-Oriented Learning Environment) is a constructivist pedagogical approach to empower computer game-based learning. This approach 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. All missions, tasks and problems therein are generative and open-ended with neither prescribed strategies nor solutions. With sophisticated multi-player simulation contexts and teacher facilitation (scaffolding and debriefing), VISOLE provides opportunities for students to acquire both subject-specific knowledge and problem-solving skills through their near real-life gaming experience. This chapter aims to delineate the theoretical foundation and pedagogical implementation of VISOLE. Apart from that, the authors also introduce their game-pedagogy co-design strategy adopted in developing the first VISOLE instance—FARMTASIA.

INTRODUCTION

The young generation loves computer games (Prensky, 2006). Even if computer gaming is prohibited at school or at home, youngsters will make all attempts to conduct this beloved activity somewhere else, such as game arcades, cyber cafés, or even game sellers' free demo machines on the streets. This "addiction" has been one of the common premises of

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various studies on harnessing games[1] in education in recent decades (e.g., Adam, 1998; Bisson & Lunckner, 1996; Bowman, 1982; Buckingham & Burn, 2007; Cameron, 2008; Crookall & Saunders, 1989; Gredler, 2004; Hub, 2008; Malone, 1980, 1981; Squire, 2005).

Most of the early research of game-based learning focused on investigating what, why, and how gaming can make the process of learning more interesting (e.g., Bowman, 1982; Malone, 1980, 1981). The basis of those studies was the ability of games to let players have fun and enjoyable experiences. Fun and enjoyment are essential elements in the process of learning as students can be more relaxed and motivated to learn (Bisson and Luncker, 1996). Players 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.

In recent years, along with the advancement of gaming technology, the focus on game-based learning has shifted onto the issue of how to harness the ability of games to sustain spontaneous players' engagement and exploit proactive players' communities for students' constructivist learning (e.g., Aylett, 2006; Egenfeldt-Nielsen, 2007; Lee, Lee & Lau, 2006; Gee, 2003, 2005; Prensky, 2001, 2006; Shaffer, 2006; Squire, 2005). For example, Adam (1998) and Squire (2005) studied the opportunities to utilize some prevalent recreational games in the commercial market for activity-based learning at school. Shaffer (2006) and his colleagues developed a number of *epistemic games* for students to participate in simulations of various professional communities in a self-directed manner. Lee, Lee, and Lau (2006) proposed *Folklore-based learning* which portrays a new design paradigm of educational games. Apart from that, in this chapter, we introduce *VISOLE* (Virtual Interactive Student-Oriented Learning Environment)—a constructivist pedagogical approach to game-based learning. In VISOLE, we adopt a game-pedagogy co-design strategy for facilitating students' multi-disciplinary knowledge acquisition and problem-solving skill enhancement. We also emphasize the importance of teachers and their roles therein.

After the introduction, the rest of the chapter is organized as follows. Firstly, we discuss the background of game-based learning and some recent research foci in the domain. After that, we delineate the theoretical foundation and pedagogical tactic of VISOLE, followed by a description of FARMTASIA—the first instance of VISOLE. Further, we discuss some emerging issues of game-based learning, before our concluding remarks are given.

BACKGROUND

The discussion of harnessing games for teaching and learning has started since the widespread popularity of Pac-Man in the early 1980s (Squire, 2003). Without doubt, the "games" discussed in most of today's game-based learning research are quite different from the ones that were used in education in the last few decades. The differences are not only in games' technical enhancement (e.g., more sophisticated 3D user interfaces, dynamic synchronous players' interaction, etc.) brought by the advancement of technology, but also their underpinning learning philosophy, shifting from behaviourism (Rachlin, 1991; Skinner, 1938) to constructivism (Bruner, 1960; Papert, 1993; Piaget, 1964, 1970).

Behaviourist Game-Based Learning

Behaviourism was the dominating learning philosophy adopted in the design of so-called "educational games," when games were introduced to education initially (Egenfeldt-Nielsen, 2007). The behaviourist conception in education advocates that a human's mind can be treated as a black box (Skinner, 1938). The 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 certain stimulus. Learning can be imposed by conditioning and reinforcement.

One of the typical genres of "behaviourist" educational games is drill-and-practice games. This type of games usually has a clear reward structure that is used as a way to push students' learning forwards. It is assumed that students can be put in front of computers, and then learn content and skills with drill-and-practice games, without teachers' help or involvement. For example, in *Math Blaster!*[2], students have to shoot down the right answer to the mathematics question shown on the screen. On each success, the player's balloon will move towards a needle. A student who can pop his/her balloon eventually will win the game. Egenfeldt-Nielsen (2007) criticized that drill-and-practice games lack integration of learning experience into gaming experience. These games rely only on extrinsic motivation (Malone, 1980, 1981) through arbitrary rewards. "Parrot-like" learning will result in weak transfer and application of knowledge and skills (Gee, 2003; Jonassen & Howland, 2003).

Constructivist Game-Based Learning

Constructivism is a common underlying learning philosophy in most contemporary game-based learning research (e.g., Aylett, 2006; DiPetro, Ferdig, Boyer & Black, 2007; Gee, 2003, 2005; Lee et al.'s 2006; Shaffer, 2006; Squire, 2005). In direct contrast to behaviourist learning, constructivist learning emphasizes that students should construct knowledge on their own. Students' learning is not imposed simply by conditioning and reinforcement, but rather a *cognitive* and *socio-cultural* interaction in a rich and authentic learning environment (Otting & Zwaal, 2007). A gaming environment is a possible room for constructivist learning to take place (Gee, 2003; 2005; Prensky, 2001, 2006; Shaffer, 2006).

When discussing the potential of game-based learning in the cognitive and socio-cultural aspects, we should first classify today's games (either educational games or recreational games) into *mini-games* or *complex-games* (Prensky, 2006). In general, playing mini-games takes around several minutes to an hour. Usually, these games contain simple challenges and content, with neither ethical dilemma nor human players' interaction. In contrast to mini-games, complex-games require players' dozens of hours (or even more) of concentrated attention to master. Most tasks therein are generative and open-ended without prescribed gaming strategies. Players have to analyze the perceived information and context in complex games cognitively. It is also necessary for them to acquire new and multiple skills, and interact (compete, cooperate or collaborate) with other *human* players, or *NPCs* (non-player characters) in the games social-culturally. This sort of gaming experience coincides with Lave and Wenger's (1991) conception of *situated learning*.

Complex-games create new cognitive and socio-cultural learning opportunities for students to acquire knowledge and skills in a constructivist fashion. Contemporary game-based learning researchers (e.g., Aylett, 2006; Ip, Luk, Cheung, Lee & Lee, 2007; Shaffer 2006; Squire, 2005) have been endeavouring to study how complex-games (hereafter referred as games) can be harnessed in education. In general, their work can be categorized into two research foci, namely, *education in games*, and *games in education.*

Education in Games

Gee (2003, 2005) has been advocating the exploration of the possibility of adopting recreational games in the commercial market for educational use. He argued that many bestselling recreational games (e.g., *Full Spectrum Warrior*[3]) are already "state-of-the-art" learning games as they are hard but fun, time-consuming but enjoyable, and complex but "learnable." As one of proponents of Gee, Squire (2005) studied how to integrate a prevalent recreational game, *Civilization III*[4], into US high-school classrooms for World History teaching. This game allows players to lead a civilization from 4000 BC to the present, with a mission to 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. Some other research of education in games includes Adams's (1998), Betz's (1995), and Prensky's (2001) studies examining the educational potential of *SimCity 2000*[5].

Some researchers (e.g., Rice, 2007) realize that the education-in-game approach is more appropriate for informal learning than school education. It is because recreational games in the commercial market are designed originally for entertainment purpose, rather than education purpose. Teachers will have difficulties in finding recreational games in which the content and context are compatible with school curricular (Mishra & Foster, 2007). Apart from that, most recreational games offer only little or even no degree of "pedagogical adjustment" (Deubal, 2002) for teachers when integrating the games into their teaching practice.

Games in Education

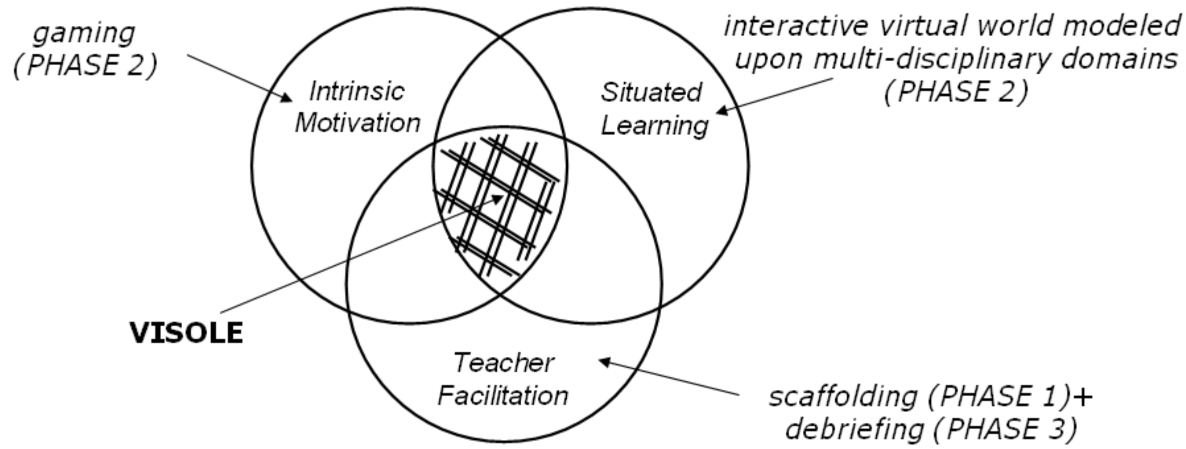
Instead of utilizing existing recreational games, some game-based learning researchers design their educational games based on different constructivist beliefs. For example, Shaffer (2006) realized that members of a profession have an *epistemic frame*—a particular way of thinking and working. Thus, developing individuals to be members of a particular profession is a matter of equipping them with a right epistemic frame. Shaffer and his colleagues developed a number of *epistemic games* which allow students to participate in simulations of various professional communities that they might someday inhabit. Lee et al. (2006) proposed a design paradigm of educational games, namely, *Folklore-based learning*. This paradigm suggests that learning takes place in an interactive adventure highlighted by problem-solving tasks which are situated in a folklore-based story plot. It is not only aimed at enabling students to learn in an authentic environment, but also offering interesting story episodes as a motivating agent for less initiated students. As prototype work, Lee et al. developed a game to realize this learning paradigm, namely, *Tong Pak Fu and Chou Heung*[6], based on the topic of probability in the Mathematics curriculum. In addition, other examples of games in education include Aylett's (2006)*narrative games* and Ip et al.'s (2007)*game-based collaborative learning platform*.

Ferdig (2006) argued that, similar to other educational tools, the ultimate impact of educational games on learning depends on the pedagogical strategies and teachers' involvement in utilizing the games in real practice. Nevertheless, not much discussion on the pedagogical framework or teachers' facilitation tactics is found in the current concerned research. We want to draw attention to this area that has been ignored in most of the game-in-education studies, and that is why we propose VISOLE (*Virtual Interactive Student-Oriented Learning Environment*)—a new pedagogical approach to game-based learning. In the following sections, we will delineate the theoretical foundation and praxis of the VISOLE pedagogy.

THEORETICAL FOUNDATION OF VISOLE

The constructivist view in education emphasizes that learning is an active process in which students construct knowledge on their own by interacting in rich and authentic learning environments (Otting & Zwaal, 2007). Hein (1998) proposed a set of principles for constructivist learning design:

Figure 1. The conceptual framework of VISOLE



- motivation is essential for learning;
- previous knowledge is a prerequisite to learning;
- learning is contextual and an active process of meaning construction;
- learning is a social activity and happens with other learners;
- experience plus reflection equals learning.

In the theoretical context of constructivist learning, (1) *intrinsic motivation*, (2) *situated learning*, as well as (3) *teacher facilitation* are united to construct the conceptual framework of VISOLE (see Figure 1). Based on this framework, VISOLE is concretized further into three operable pedagogical phases, namely *Multi-disciplinary Scaffolding* (Phase 1*), Game-based Situated Learning* (Phase 2), and *Reflection and Debriefing* (Phase 3). We will focus on discussing the conceptual framework of VISOLE in the current section, while the pedagogical phases will be presented in the next section.

Intrinsic Motivation

Constructivist learning theorists (e.g., Papert, 1993; Piaget, 1964, 1970) realize that intrinsically motivated play-like activities can foster students' deep learning. It is because, in those activities, students are willing to spend more time and effort on learning. They also feel better about what they learn, and will try to apply the acquired knowledge and skills in the future.

According to Malone's (1980, 1981) theory of intrinsic motivation in learning, students are said to be motivated intrinsically if they engage in a learning activity for its own sake, rather than some external rewards. Malone argued that learning through gaming is an effective means for triggering students' intrinsic motivation because of the three intrinsic motivating elements of computer games: (1) *challenge*, (2) *fantasy*, and (3) *curiosity*. Apart from that, Bowman (1982) tied his intrinsic motivation study on gaming and learning, with Csikszentmihalyi's (1975, 1990) psychological conception—*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 the challenge. Bowman believed that learning through gaming is a spontaneous way to bring students to the flow state of learning. Although Bowman's work was done more than two decades ago, recent empirical evidence (e.g., DeLisi & Wolford, 2002) still accord with his assertion.

The issue of how to get students motivated intrinsically and with the feeling of immersion is one of the essential considerations in constructivist learning design (Cordova & Lepper; 1996; Martens, Gulikers & Bastiaens, 2004). Thus, we use a gaming strategy to trigger students' intrinsic motivation in VISOLE.

Situated Learning

Papert (1993) observed that knowledge is often fragmented into small and disconnected pieces of learning content in traditional classrooms. The original intention of this act is to make learning easier. However, it usually ends up neglecting the rationale behind the knowledge itself, creating unrealistic learning contexts, and rendering the whole learning process boring.

Lave (1988) argued that, learning is neither an individual nor impersonal process, but a course of *situated cognition*. The premise underlying situated cognition is that all knowledge, skills, and ability are dependent on the contextual and social-cultural situations in which they are acquired. Thus, the issue of education is not seen as how to build representations in each student's head, but how to engage them in near real-life situations through contextual and socio-cultural interactions (Wenger, 1998). This is so-called *situated learning* (Lave & Wenger, 1991), in which learning takes place unintentionally rather than deliberately. CTGV—*Cognition and Technology Group at Vanderbilt* (1993) applied situated learning in the area of technology-based learning activities focusing on the enhancement of students' problem-solving skills.

With today's advanced gaming technology, game-based learning is recognized as an appropriate embodiment of situated learning that Lave and Wenger (1991) delineated (Egenfeldt-Nielsen, 2007; Huh, 2007; Prensky, 2001, 2006; Shaffer, 2006). An interactive gaming environment modeled upon multi-disciplinary domains can facilitate students' contextual and socio-cultural learning in near real-life situations that entwine *practice*, *participation*, *community,* and *identity* (Wenger, 1998). Most tasks in this environment are open-ended. In order to accomplish the tasks, students have to interact (compete, cooperate or collaborate) with other *human* players or *NPCs* (non-player characters) therein social-culturally. In other words, they are involved in a community of practice which embodies certain beliefs and behaviour to be acquired, i.e., knowledge construction. We term the process of students' gaming in VISOLE as *game-based situated learning*.

Teacher Facilitation

Egenfeldt-Nielsen (2007) and Ferdig (2007) realized that it is not sufficient to look at students' intrinsic motivation in gaming, or games as a sophisticated contextual and socio-cultural learning device, and then assert knowledge can flow and be transferred automatically among students in game-based learning. DiPetro et al. (2007) argued that leaving students to float amidst rich experience without teachers' help in the process of game-based learning may not work effectively. According to other constructivist learning approaches, such as problem-based learning (Barrows, 1996), and project-based learning (Krajcik & Blumenfeld, 2006), teachers' facilitation of the activation of students' *prior knowledge* (Hein, 1998), and formulation of students' *reflective habits* (Dewey, 1938) are always of primary importance. There is no exception in game-based learning. Scaffolding (Vygotsky, 1978) and debriefing (Thiagarajan, 1998) are the conceptual bases framing the teacher facilitation design in the VISOLE pedagogy.

Scaffolding

Every new and meaningful learning starts from students' prior knowledge (Wellington, 2006). Vygotsky's (1978)*scaffolding* conception offers clues to frame what, how, and how much teachers should activate students' prior knowledge. Scaffolding refers to a process by which a teacher assists students so that they can solve problems or perform tasks that would otherwise be out of reach. The teacher scaffolds should be removed gradually as the students begin to take on more control and responsibility about the problems or the tasks. For the scaffolding to be effective, the teacher scaffolds should be set inside the so-called *zone of proximal development* (ZPD). The ZPD is the area between *the level at which a student knows something or can do something on his/her own* (namely, Zone A), and *the level of performance or skill he/she could reach if the right intervention is offered* (namely, Zone B). The teacher scaffolds function as a "bridge" so as to assist students in "walking across" the ZPD, from Zone A to Zone B.

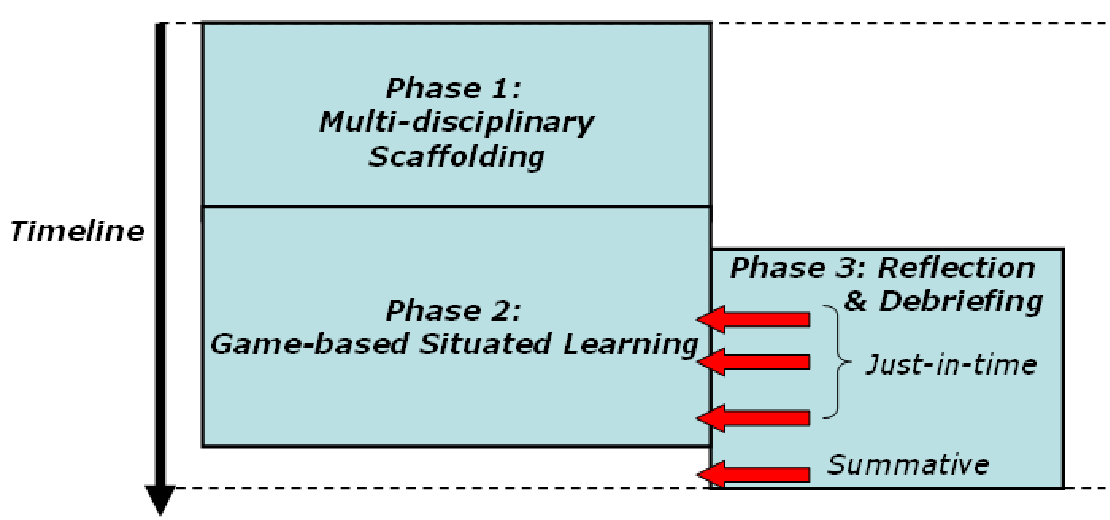
Debriefing

Besides the issue of how to activate students' prior knowledge, in the process of game-based learning, students often have difficulties in making connections between the scenarios happening in a game and the corresponding real-world system that the game intends to represent (Clegg, 1991). Moreover, games make assumptions and inevitably contain bias (Thiagarajan, 1998); even a game designed with high-fidelity simulations cannot represent reality.

Learning is experience plus reflection (Dewey, 1938). Thus, gamers become learners if they can often reflect on their experience in gaming (Salen, 2007; Schon, D, 1983). *Debriefing* (Thiagarajan,1988) is a process to help students reflect on their gaming experience.

Usually, debriefing is conducted by a teacher, which allows students to engage in reflective and meta-cognitive thinking that transforms their gaming experience into learning experience. One of the crucial aims of debriefing is to let students correspond the things happening in games to real-life context, so as to correct the misconceptions in their minds. In fact, a number of researchers (e.g., Garris, Ahlers & Driskell, 2002; Mayer, Mautone & Prothero, 2002; Prensky, 2001) be-

Figure 2. Three pedagogical phases of VISOLE



lieve that debriefing is one of the most critical components in game-based learning. Furthermore, Thiagarajan (1988) proposed a set of strategies for game-based learning teachers to apply in their debriefing lessons, such as *role dropping*, *insight sharing*, *real-world transfer*, *what-if analysis*, and *second thoughts*.

A CLOSE LOOK AT VISOLE

Based on the theoretical foundation, we frame VISOLE as three operable pedagogical phases, namely *Multi-disciplinary Scaffolding* (Phase 1), *Game-based Situated Learning* (Phase 2), and *Reflection and Debriefing* (Phase 3), as diagrammatically shown in Figure 2. Please note that Phase 2 and Phase 3 take place in an interlacing fashion, but Phase 2 starts a bit earlier than Phase 3.

Phase 1: Multi-disciplinary Scaffolding

VISOLE teachers act as cognitive coaches to activate VISOLE students' learning motive, and assist them in gaining some preliminary high-level abstract knowledge (prior knowledge) based upon a selected multi-disciplinary framework. In this phase, students are equipped with "just enough" knowledge, and given only some initial "knowledge pointers." They have to acquire the necessitated knowledge and skills on their own in the next learning phase, not only from the designated learning resources but also a wider repertoire of non-designated learning resources, such as the Internet.

Phase 2: Game-Based Situated Learning

This phase 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. The game encompasses the creation of a virtual interactive world in which each student plays a role to shape the development of this world for a period of time. The missions, tasks and problems therein are generative, and there is no prescribed solution. Since every single action can affect the whole virtual world, students have to take account of the overall effects associated with their strategies and decisions on others contextually and socio-culturally. "Being situated" in this virtual world, not only do students have to acquire the subject-specific knowledge in a multi-disciplinary fashion, but they also need the generic skills of problem analysis, strategy composition, decision making, etc.

Phase 3: Reflection and Debriefing

This phase interlaces with the activities in Phase 2. After each gaming session, students are required to write their own reflective journal to internalize their learning experience in the virtual world in a just-in-time fashion. Moreover, at the end of this phase, they are required to write their own report in a summative fashion to reflect on their overall learning experience. In addition, teachers monitor closely the progress of students' development of the virtual world at the backend, and look for and try to act on "debriefable" moments to "lift" students out of particular situations in the game. Respectively during the course and at the end of this phase, teachers extract problematic and critical scenarios arising in the virtual world, and then conduct just-in-time and summative case studies with their students in face-to-face debriefing classes.

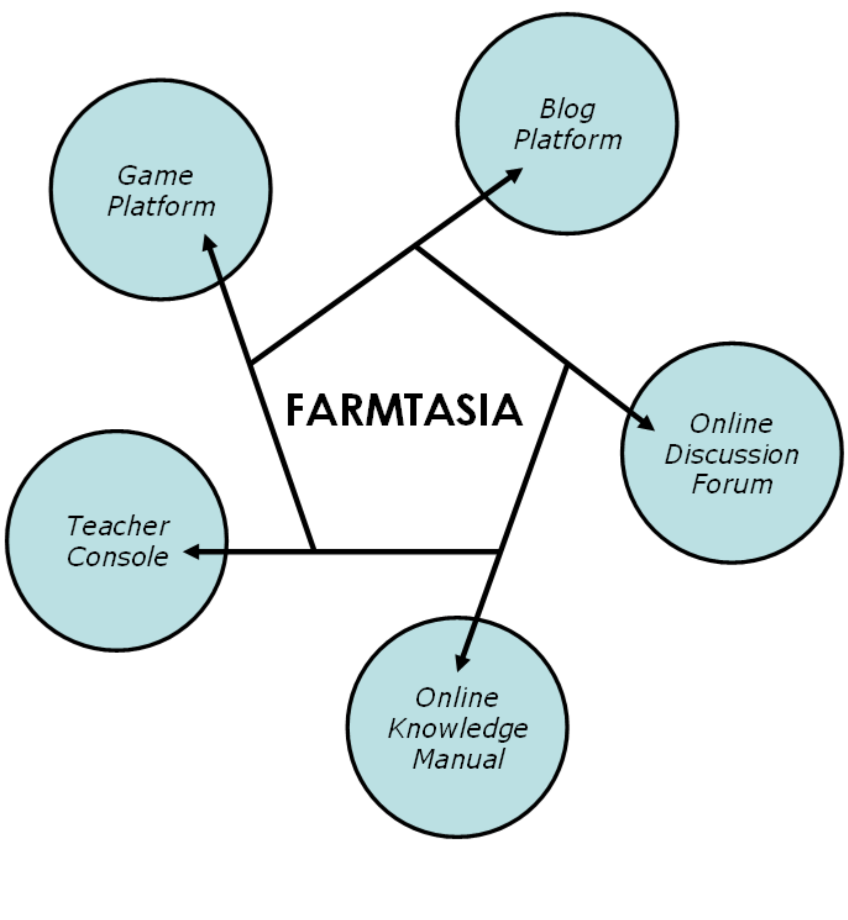
FARMTASIA: AN INSTANCE OF VISOLE

FARMTASIA[7] is the first instance of VISOLE. The multi-disciplinary content of FARMTASIA was designed based on the Hong Kong senior secondary curriculum. It involves subject areas of *geography*, *biology*, *economics*, and *technology*, while the "virtual world" is composed of interacting farming systems. Figure 3 shows the five components (*the game platform*, *teacher console*, *online knowledge manual*, *online discussion forum*, and *blog platform*) implemented in FARMTASIA. In this section we will delineate how these components support the VISOLE pedagogy.

Game Platform

FARMTASIA's game platform enables Phase 2 of VISOLE *(Game-based Situated Learning)*. It deploys interacting farming systems, covering the domains of *cultivation*, *horticulture*, and *pasturage*. The "virtual world" therein is modeled upon the multi-disciplinary knowledge of *geography* (natural environment and hazards, as well as environmental problems), *biology*, *economics* (including government and production system), and *technology*. In this world, each player *(the term "player(s)" and "student(s)" are interchangeable hereafter)* acts as a *farm manager* to run a farm which is composed of *a cropland*, *an orchard*, and *a rangeland*. Each player competes for financial gain and reputation with three other farm managers who are also at the same time running their own farm somewhere nearby in the same virtual world. Throughout the gaming period, players have to formulate various investment and operational strategies to yield both

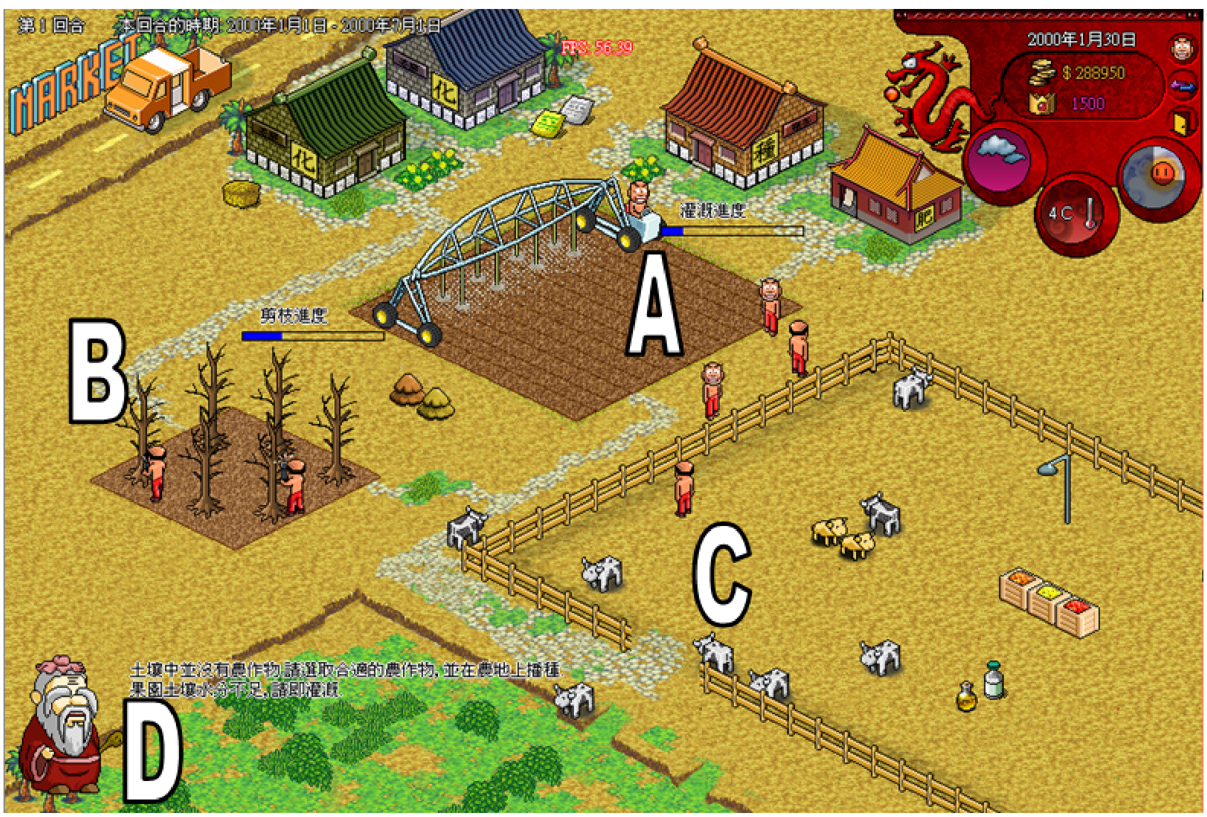
Figure 3. Five components implemented in FARMTASIA



quality and abundant farm products for making a profit in the market. They should always keep an eye on the contextual factors *(e.g., temperature, rainfall, wind-speed, etc.)* of the virtual world so as to perform some just-in-time actions, such as cultivating and reaping crops at appropriate time. Scheduling tasks for farm workers to conduct fertilization, irrigation and grazing is another critical issue that players should also pay attention to. In spite of the competition for financial gain, the richest may not be the final winner, because players' final reputation in the virtual world is another crucial judging criterion. The reputation index is governed by good public policies and is determined by players' practice on sustainable development and environmental protection. *Wise Genie*, who is an NPC (non-player character), will appear in the virtual world for giving advice or hints to players in some critical moments. Figure 4 shows the gaming interface of FARMTASIA.

In this virtual world, players can fall into dilemmas easily. For example, buying machinery needs large initial investment, but may be able to boost the quantity of the farm outputs. Keeping more livestock will increase the daily operational cost of the farm, but livestock's excrement can be used as a sort of organic fertilizer for nurturing the cropland and the orchard so as to achieve sustainable development. Apart from that, as in real-life, hard work does not guarantee rewards,

Figure 4. The gaming interface



(A) Cropland, (B) Orchard, (C) Rangeland, & (D) Wise Genie

and sagacity may not come along with fortune. Catastrophes from the nature, and disasters caused by other farm managers can ruin one's achievement in a single day. Nevertheless, by setting a range of precaution measures, "wise" players can often minimize their loss in the catastrophes and disasters.

Scientific Models

FARMTASIA's game context is based on real data simulation articulating sophisticated scientific models. For example, both botanical and biological models are adopted to simulate how crops and livestock evolve in a near real-world way. In the virtual world, players can experience how their crops sprout, flourish and wither, and witness how their livestock grow and propagate themselves. Figure 5 shows a crop's sowing-harvesting relationship against time. In addition, a geographical model is adopted to create the four-seasoned climate, which alternates wind-speed, temperature and rainfall in the virtual world. (see Figure 6) Concerning the economics in the virtual world, an economic model is adopted to deal with the exchange of labour, farm products, and revenues.

Unforeseen Events

The game system will generate various *unforeseen events* in the virtual world on a random basis. Framing a workable solution to cope with an unforeseen event requires players to analyze every current happening in the virtual world in a contextual and socio-cultural fashion. The unforeseen events will emerge in the form of *local*, *market*, and *mass* issues:

- *Local Issues*. These issues may lead to the risk of a farm closure but without causing inter-farm consequential effects in the virtual world. Examples include fire accidents, workers' strikes, invitations to debit bank loan, etc. See Figure 7.
- *Market Issues*. These issues arise in either the provincial or global market, and will cause consequential effects on all farms in the virtual world. Examples include market-price fluctuations in farm products, outbreaks of bovine spongiform encephalopathy (mad-cow disease), etc. See Figure 8.
- *Mass Issues*. These events involve cooperation and collaboration among players in the virtual world, and will cause interactive effects therein. Examples include raising funds to build a dam, accusing an entrepreneur of plastic industry whose factories pollute the water sources, etc. See Figure 9.

Situating players in these unforeseen events can provide them with opportunities to sharpen their ability to deal with contingency and emergency.

Mini-games

Besides the main game, players will be assigned to play a mini-game in every round of gaming. One of the key purposes of the mini-game inclusion is to motivate players to pursue their learning in the virtual world.

A set of mini-games are designed corresponding to the routine but essential activities that have to be conducted in a real-life farm, such as cutting off rotting fruits in the orchard (see Figure 10 and 11). These mini-games are competitive in nature, and players compete for better scores therein. Their performance in the mini-games will affect how well the relevant activities are carried out in their own farm. This is because players' good performance in the mini-games will be rewarded with better overall managerial and financial abilities in the virtual world.

Figure 5. Botanical model: Sowing-harvesting relationship against 12 months

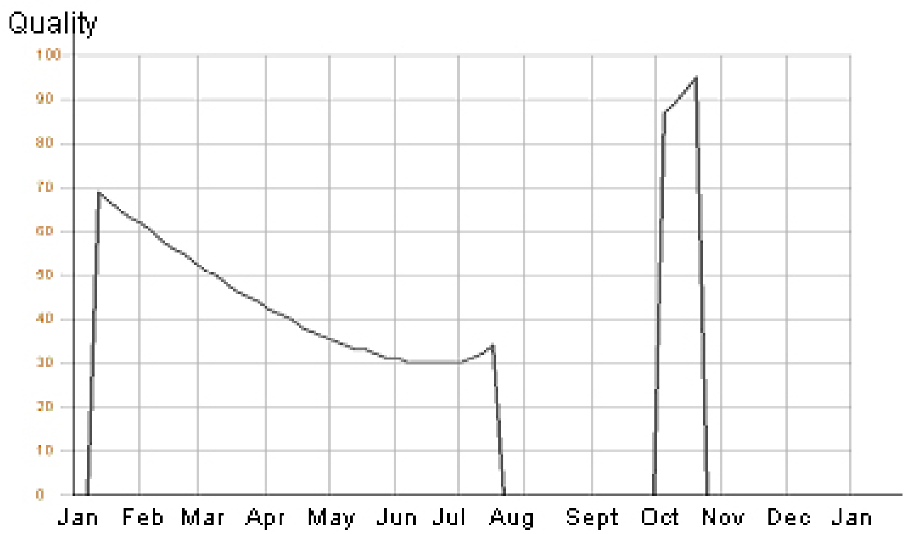
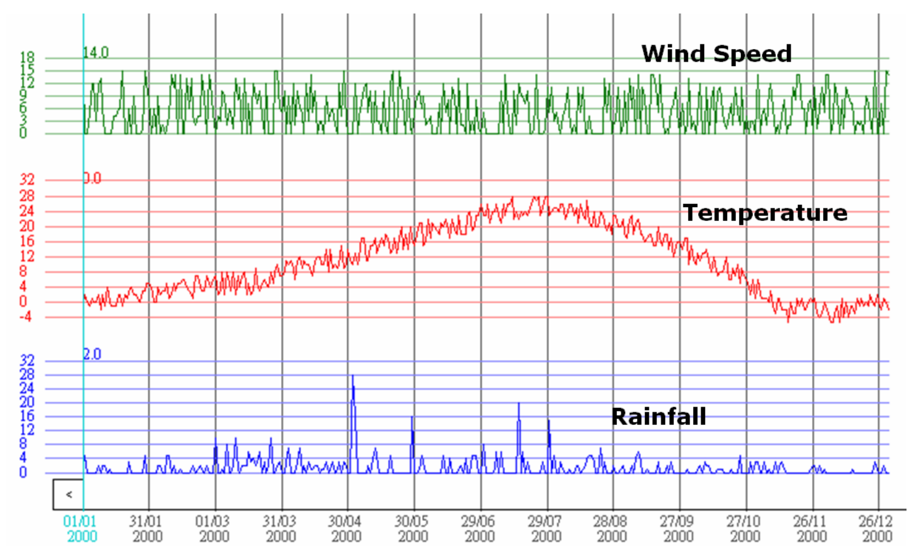


Figure 6. Geographical model: Wind-speed, temperature and rainfall against 12 months



Teacher Console

In Phase 3 of VISOLE *(Reflection and Debriefing)*, teachers need to monitor the progress of students' development of the virtual world, and then give debriefing for facilitating students' reflection on their gaming experience. One of the key functions of the *teacher console* of FARMTASIA is to assist teachers in preparing and conducting their debriefing classes.

While students run their farm in the virtual world, the game server *records* their every single gaming action. Teachers can review all students' gaming histories through the teacher console. The

Figure 7. Unforeseen events: Do you need more money for investing in your farm?

Figure 8. Unforeseen events: Market-price fluctuations in farm products

Figure 9. Unforeseen events: Accusing a polluting factory cooperatively

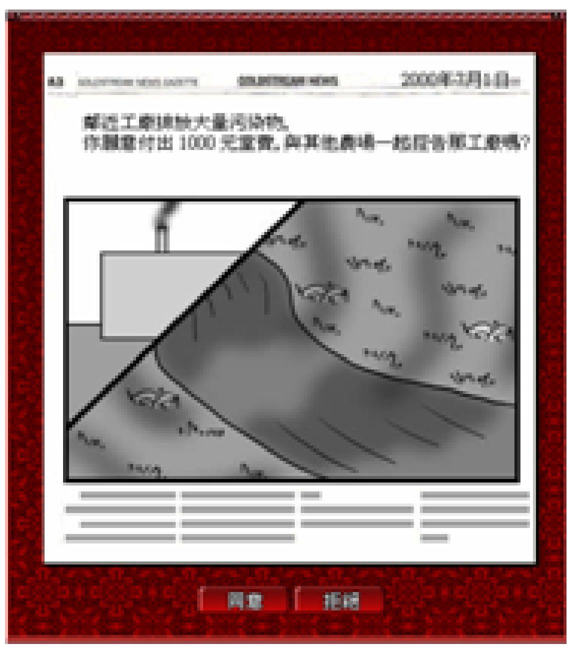


Figure 10. Example of mini-games: Scare-crowing birds

Figure 11. Example of mini-games: Cutting off rotting apples

console interface presents the histories in Gantt chart format (see Figure 12. Every rectangular block in a Gantt chart represents the proceedings of a student in a particular timeslot. By clicking the block, teachers can *replay* the proceedings in a form of *video playback* (see Figure 13. This function is termed *record-and-replay* function of the teacher console.

With the record-and-replay function, teacher can look for and extract interesting, problematic, or critical scenarios taking place in the virtual world to conduct just-in-time and summative case studies with their students. Since all these scenarios come from students' actual gaming experiences, it is easier for them to recognize, empathize, and understand the constructive and destructive occurrences therein, and the corresponding enhancement and corrective actions. Teachers can also ask students to perform *what-if analysis* or have *second thoughts* (Thiagarajan, 1988) based on

Figure 12. Student's gaming history: Gantt chart

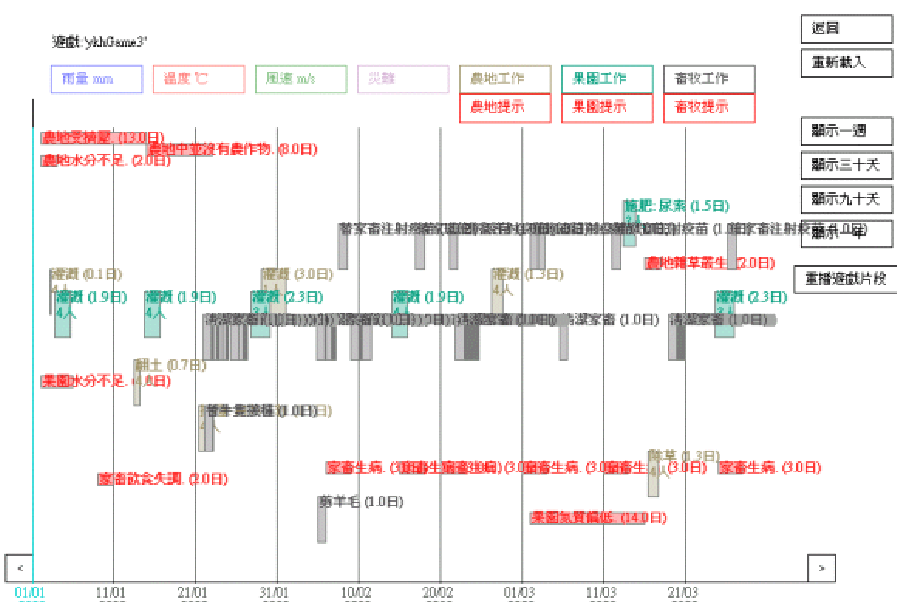


Figure 13. Student's gaming history: Student's gaming proceedings as video playback

these scenarios so that students can have deeper reflection on the differences between their current outcomes and other possible outcomes with respect to other possible acts.

Apart from the *record-and-replay* function, the teacher console can also allow teachers to inject "artificial" catastrophes, such as twisters and tsunamis into the virtual world (see Figure 14 and Figure 15). Like the unforeseen events, situating players in these artificial catastrophes provides them with opportunities to sharpen their ability to deal with contingency and emergency.

Online Knowledge Manual

As mentioned in the previous sections, FARMTASIA's "virtual world" is modeled upon the multi-disciplinary knowledge of *geography* (natural environment and hazards as well as environmental problems), *biology*, *economics* (including government and production system) and *technology*. In parallel with the development of the game platform, we also created an *online knowledge manual* (see Figure 16) which covers all under-

Figure 14. "Artificial" catastrophes

Figure 15. "Artificial" catastrophes

Figure 16. The online knowledge manual

lying multi-disciplinary knowledge employed to model the virtual world.

This manual serves two proposes. Firstly, it is a reference guide for teachers to prepare and frame their scaffolding lessons in Phase 1 of VISOLE *(Multi-disciplinary Scaffolding)* for equipping students with high-level abstract knowledge required in FARMTASIA. Secondly, this manual is a learning resource bank for students to look up when they meet some unsolvable problems or difficulties arising in the virtual world in Phase 2 of VISOLE *(Game-based Situated Learning)*.

Online Discussion Forum and Blog Platform

An online discussion forum (See Figure 16) is provided as an off-the-game collaborative learning platform for students to discuss both gaming and learning issues arising in Phase 2 of VISOLE *(Game-based Situated Learning)*. Furthermore, in order to motivate students to write their daily game-based learning journal to reflect on their learning experience, a *blogging* approach is harnessed in Phase 3 of VISOLE *(Reflection and Debriefing)*. Students are required to "blog" their reflection after each round of gaming (see Figure 17). They can also view and reply to other students' blog without restriction. Three reflective questions are provided on the blog platform so as to scaffold students to conduct their reflection on their learning experience in a more focused manner, rather than some superficial gaming experience. The questions are:

- How is the current condition of your farm?
- What have you learned in this round?
- Based on the new knowledge and skills you learnt in this round, will you adjust your strategies in the next round of gaming? How?

Figure 17. The online discussion forum and the blog platform

Both online discussion and blogging in the VISOLE process offer additional opportunities for students to interact with one another socio-culturally. This favours situated learning to take place (Lave, 1988; Lave and Wenger, 1991). Besides, the artefacts on the discussion forum and blog platform provide extra information for teachers to frame and conduct their debriefing classes.

FURTHER DISCUSSION

Some recent empirical studies (Jong, Shang, Lee & Lee, 2007a; Jong et al., 2007b; Shang, Jong, Lee & Lee, 2008) investigating the educational realization and accomplishment of the VISOLE pedagogy have been carried out in Hong Kong. In those studies, the participants were secondary-4 (K-10 equivalent) students and their teachers, while FARMTASIA was adopted as the VISOLE instance[8]. Results showed, after the VISOLE process, there was a significant enhancement in the students' multi-disciplinary knowledge, and problem-solving skills in terms of "self," "information," "collaboration," and "task" management (Bennett, Dunne & Carre, 1999). Apart from that, the majority of the teachers were positive towards the use of this pedagogical approach to harness games in education. However, the insufficiency of time for reviewing the students' gaming histories and preparing the debriefing classes was one of the main difficulties that the teachers encountered during the implementation process. They commented that it was rather time-consuming in selecting suitable case-study scenarios from the gaming proceedings with the teacher console. Notwithstanding this, they did suggest some possible ways to improve the existing console. For instance:

Like sports games ... it would be great if the teacher console can analyze students' gaming data automatically, and then generate a set of possible case-study scenarios, like the highlights in soccer games ... for example, a student suddenly earns a lot of money or there is a dramatic drop of his reputation in the game. We can use these scenarios to conduct debriefing classes.

Improving the existing teacher console is of critical importance to the further development of our game system; otherwise, the inefficient use of the console will become a barrier to teachers implementing the VISOLE pedagogy in practice.

In fact, similar to other tools or media when they were first introduced to schools, studying barriers to the educational use of games has become one of the interests in this research domain. For example, Rice (2007) in his empirical study argued that *stakeholders' (e.g., school principals, teachers, and parents) negative perceptions of gaming*, *unattractive educational games to students*, and *insufficient computing hardware for gaming at school* are the dominating barriers to harnessing games in education. Rice's study focused mainly on the entrance barriers to the introduction of games into schools. However, little light was shed on the actual emerging barriers which impede the effectiveness of students' learning and teachers' facilitation in the process of game-based learning at the classroom level. In the current research context, there is still a lack of comprehensive understanding of the barriers that might obstruct the successful implementation of game-based learning in school education.

CONCLUSION

Ferdig (2007), in the preface of a journal's special issue—*Learning and Teaching with Electronic Games,* called for answers to the question of how educational gaming in constructivist fashion will look like. DiPietro et al. (2007), Egenfeld-Nielsen (2007), and Mishra and Foster (2007) argued that although the educational potential of game-based learning has been discussed widely and with strong theoretical arguments, there is still a distance to put it in place, particularly regarding the pedagogical consideration. We have attempted to address the issue by introducing the VISOLE pedagogy—one of the possible ways to harness games in education.

In this chapter, we have introduced the background of game-based learning, from the behavourist learning paradigm in the early 1980s to the recent constructivist learning paradigm, and from its original purpose of "sugaring the pills" to today's purpose of sustaining learners' intrinsic engagement and exploiting cognitive and socio-cultural learning environments. Furthermore, we have elaborated two recent genres of research in the domain—*education in games,* and *games in education*. VISOLE is an instance of games in education. However, the educational paradigm is a bit different from some other work in the same genre.

Despite a great promotion of the shift in education from a traditional, didactic model of instruction to a learner-centered model that emphasizes a more active learner role, the educational paradigm of VISOLE advocates strongly that teachers are always the best at seeing when, what and why learners have difficulties and assisting them in looking for possible solutions in the process of learning (Howard, 2002; Jonassen, 1998; Lee, 2002). We believe even a well-designed educational game per se is unlikely to facilitate learning effectively, unless opportunities of initial enablement, reflection and generalization of abstraction are embedded in the whole gaming process in an appropriate way. This needs human-medication therein, and that is why we propose VISOLE.

VISOLE is a three-phase constructivist pedagogical approach to game-based learning, in which, the importance of teachers' roles are emphasized. FARMTASIA is the first illustration of VISOLE. In this chapter, we have also discussed briefly some VISOLE empirical research findings that were presented in some recent international conferences (Jong et al., 2007a, 2007b; Shang et al., 2008).

By introducing VISOLE, we hope we can generate a flash of inspiration for other game-based learning researchers, educators, school teachers, game designers, as well as game companies, when reflecting on the questions of what, why, how, and when gaming can be educational. More mature and comprehensive frameworks for the educational use of games (*either the education-in-games approach or games-in-education approach)* will emerge soon, provided that we continue to pursue an open-discussion and conversation within multiple fields and disciplines.

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ENDNOTES

1 Unless otherwise specified, the term "game(s)" refers to "computer game(s)."

2 *Math Blaster* is an educational game for children aged 6-9 to assist them in learning the criteria for Key Stage 1 and 2 mathematics skills. http://www.smartkidssoftware.com/nddav31.htm (Retrieved on August 28, 2008)

3 http://www.fullspectrumwarrior.com/ (Retrieved on July 28, 2008)

4 http://www.civ3.com/ (Retrieved on July 28, 2008)

5 http://www.sc3000.com/sc2000/ (Retrieve July 28, 2008)

6 http://www.cse.cuhk.edu.hk/~mhp/ (Retrieved on July 30, 2008)

7 FARMTASIA is a collaborative project conducted by Centre for the Advancement of Information Technology in Education, and Department of Geography and Resource Management at The Chinese University of Hong Kong. The system design and other technical aspects of FARMTASIA have been documented in Cheung, Jong, Lee, Lee, Luk, Shang, and Wong's (2008) recent publication.

8 For the details of the research deign and findings of those empirical studies mentioned in this section, please refer to the work of Jong et al. (2007a, 2007b) and Shang et al. (2008).