

# An Evaluative Study on VISOLE—Virtual Interactive Student-Oriented Learning Environment

Morris S.Y. Jong, Junjie Shang, Fong-lok Lee, and Jimmy H.M. Lee

**Abstract**—Virtual Interactive Student-Oriented Learning Environment (VISOLE) is a constructivist pedagogical approach to game-based learning. It encompasses the creation of a near real-life online interactive world modeled upon a set of multidisciplinary domains, in which each student plays a role in this “virtual world” and shapes its development. With sophisticated multiplayer simulation context and teacher facilitation, VISOLE aims at providing opportunities for students to acquire subject-specific knowledge in a multidisciplinary manner as well as sharpen their generic skills for problem solving. With a combination of quantitative and qualitative methods of inquiry, an evaluative study on VISOLE was conducted in Hong Kong, involving the deployment of VISOLE in 16 schools (with 254 students and 28 teachers). Notwithstanding, the positive quantitative findings (the students’ advancement in the knowledge and problem-solving generic skills concerned) of the study, the qualitative data revealed that some phenomena which emerged during the VISOLE process impeded the students’ learning process. On the other hand, some of the teachers, who also observed the same impeding phenomena, initiated or suggested some new interventions to mitigate these phenomena. The findings threw light on the issue of how to enhance the current design of VISOLE.

**Index Terms**—Education, computer uses in education, games, computer-assisted instruction.

## 1 INTRODUCTION

DIGITAL games are an important part of leisure lives of young generation. Even if gaming is prohibited at school or at home, youngsters may 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 [1]. This “addiction” has been one of the premises of harnessing games in education for years [2], [3], [4].

In the recent decade, along with the advancement of multimedia and Internet technology, as well as the pervasive promotion of student-centered educational paradigms, the focus of game-based learning has shifted from “sugaring the pill” (making boring lessons more interesting) onto the issue of how to harness the ability of games to facilitate constructivist learning. The related work includes using games to sustain learners’ engagement (e.g., [5], [6], [7], [8]), offer learners near real-life simulation-based experiences (e.g., [9], [10], [11], [12]), and exploit proactive learners’ communities (e.g., [13], [14], [15], [16]).

Constructivist learning emphasizes strongly an active student role [17], [18]. Nevertheless, upon this learning paradigm, it is still believed that teachers are always the best at seeing when, what, and why students are confronted with puzzles arising in the process of learning, and supporting them to solve the puzzles in a student-centered fashion [19], [20]. The same pedagogical idea should also apply to game-based learning [21], [22]. Hence, the discussion of game-based learning should not only focus narrowly on exploiting games into a “self-contained” constructivist learning environment. It is vital to explore how to articulate gaming and learning with teacher facilitation which assists students in transforming their gaming experience into learning experience.

VISOLE [23] is a teacher-facilitated constructivist game-based learning approach. It encompasses the creation of a near real-life online interactive world modeled upon a set of multiple real-world domains, in which each student plays a role in this “virtual world” and shapes its development. VISOLE aims at providing students with opportunities not only to acquire subject-specific knowledge in a multidisciplinary fashion, but also sharpen their generic skills for problem solving, through near real-life gaming participation. *Farmtasia* [24] is the first instance developed based on the VISOLE approach.

The focus of this paper is to discuss an evaluative study on VISOLE (with *Farmtasia*) conducted in the winter of 2006. The aim of the study was to investigate the educational realization of VISOLE. Using a combination of quantitative and qualitative methods of inquiry, we got positive results in terms of students’ advancement in the knowledge and problem-solving generic skills concerned. On the other hand, we found some phenomena which

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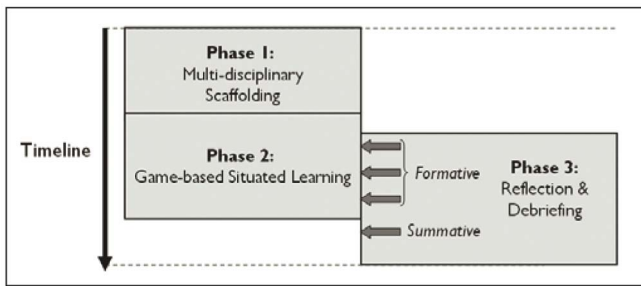


Fig. 1. Three pedagogical phases of VISOLE.

emerged during the VISOLE process impeded the students' learning process. Some of the teachers who also observed the same impeding phenomena, initiated or suggested some new interventions to mitigate these phenomena. The findings shed light on the issue of how to enhance the existing design of VISOLE.

The rest of the paper is organized as follows: In order to facilitate readers to understand the study, we provide brief descriptions of VISOLE and Farmtasia in Sections 2 and 3, respectively. Sections 4 and 5 will delineate the design and results of the study, respectively. We will give our concluding remarks in Section 6. Last but not least, further study will be discussed in Section 7.

## 2 A CLOSER LOOK AT VISOLE

VISOLE [23] is composed of three operable pedagogical phases, namely *Multidisciplinary Scaffolding* (Phase 1), *Game-based Situated Learning* (Phase 2), and *Reflection and Debriefing* (Phase 3), as shown diagrammatically in Fig. 1. As illustrated in the figure, Phase 2 and Phase 3 take place in an interlacing fashion, but Phase 2 starts a bit earlier than Phase 3. The following sections will discuss the specific tasks to be carried out by students and teachers in each phase. We will visualize further the pedagogical idea of VISOLE through the introduction of Farmtasia in Section 4.

### 2.1 Phase 1: Multidisciplinary Scaffolding

A VISOLE teacher acts as a cognitive coach to activate VISOLE students' initial learning motive. The teacher assists the students in gaining some preliminary high-level abstract knowledge (as their prior knowledge to the next learning phase) based upon a selected multidisciplinary framework through some face-to-face scaffolding lessons. In this phase, the students are equipped with "just enough" knowledge, and given only some initial "knowledge pointers." They have to go on acquiring 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 nondesignated resources, such as the Internet.

### 2.2 Phase 2: Game-based Situated Learning

This phase deploys an online multiplayer interactive game portraying a virtual world. The scenarios therein become the dominant motivator driving the students to go on to pursue the interrelated understandings of the multidisciplinary 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 open-ended, and there is no prescribed solution. Since every single action can affect the whole virtual world, the students have to take account of the overall effects associated with their strategies and decisions on others contextually and socioculturally. Being situated in this virtual world, the students have to acquire the subject-specific knowledge in a multidisciplinary fashion. Apart from that, they also need problem-solving generic skills to analyze problems occurring therein, evaluate the current gaming context and different possible solutions to solve the problems, and create optimal strategies or remedies to pursue the gaming.

### 2.3 Phase 3: Reflection and Debriefing

This phase interlaces with the activities in Phase 2. After each round of gaming, the students are required to write their own reflective journal to reflect on their learning experience in the virtual world in a formative fashion. Moreover, at the end of this phase, they are required to write their own report in a summative fashion to conclude their overall learning experience. On the teacher side, he/she monitors closely the progress of the students' development of the virtual world at the back-end. He/she looks for and tries to act on "debriefable" moments to "lift" the students out of particular situations in the game. Respectively, during the course and at the end of this phase, the teacher extracts problematic and critical scenarios arising in the virtual world, and then conducts case studies with his/her students through some face-to-face debriefing lessons.

### 2.4 Discussion

The design of different phases of VISOLE was based on the theoretical foundation of gaming and constructivism. Prior knowledge is a prerequisite to learning [25]. The "scaffolding" in Phase 1 equips students with the necessitated prior knowledge for facilitating learning to take place in the process of gaming. The "intrinsically motivated" [26] and "contextually and socioculturally situated" [27] gaming environment in Phase 2 supports students to pursue their learning in a constructivist fashion. Learning is experience plus reflection [28]. The reflective writing process in Phase 3 provides students with opportunities to transform their gaming experience into learning experience. The detailed discussion of the theoretical foundation of VISOLE can be found in [23].

## 3 FARMTASIA

Farmtasia [24] is the first instance of VISOLE. It was designed to implement the VISOLE approach. The content of Farmtasia was developed upon a multidisciplinary topic, *Agriculture*, in the senior secondary Geography curriculum of the Hong Kong Certificate of Education Examination (HKCEE) [29]. This topic involves eight areas of subject knowledge, including

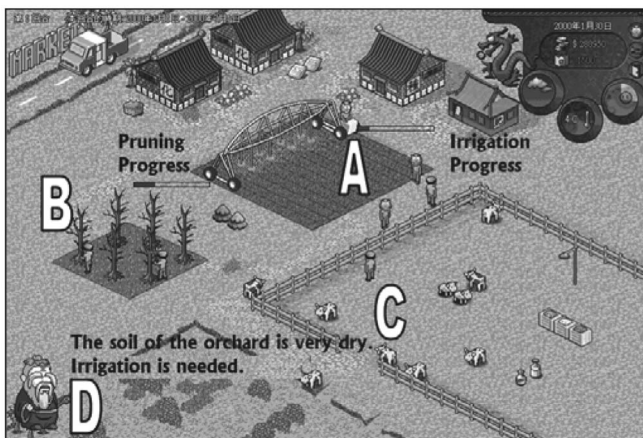


Fig. 2. Interface of the game: (A) Cropland, (B) Orchard, (C) Rangeland, and (D) Wise Genie.

1. natural environment,
2. biology,
3. government,
4. economics,
5. technology,
6. production systems,
7. natural hazards, and
8. environmental problems.

The system design and other technical aspects of Farmtasia can be found in [24].

Farmtasia is composed of four components (the game, teacher console, knowledge manual, and blogging platform) which will be elaborated in the sections below. Along with the following discussion, the terms “player(s)” and “student(s)” are interchangeable.

### 3.1 Game

This is an online multiplayer interactive game which enables Phase 2 of VISOLE. It features interacting farming systems which cover the domains of *cultivation*, *horticulture*, and *pasturage*. The “virtual world” of the game is modeled upon real data simulation based on sophisticated scientific models. Botanical and biological models are adopted to simulate how crops and livestock evolve in a near real-life fashion. A geographical model is adopted to create a four-season climate, which alternates wind speed, temperature, and rainfall therein. In addition, an economic model is adopted to deal with the market value and exchange of labor, machinery, seeds, fodder, farm products, revenues, etc.

In this virtual world, each player acts as a farm manager to run a farm which comprises a cropland, orchard, and rangeland. Each of them competes for two quantified outcomes—financial gain and reputation, with three other farm managers who are also running their own farm simultaneously somewhere nearby. Fig. 2 shows the interface of the game. Part A is a cropland for cultivating vegetables. Part B is an orchard for rearing horticultural fruits. Part C is a rangeland for keeping livestock. Part D shows the wise genie (an NPC [*nonplayer character*]) in the game. He will appear in the virtual world for giving advice or hints to players in some critical instants. The “showing-up” frequency of the wise genie will decrease in a gradual

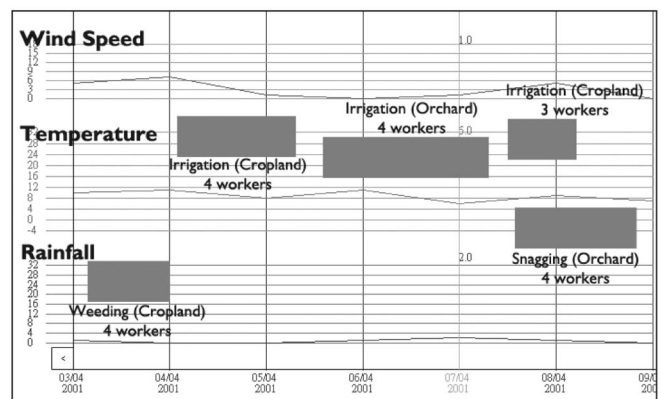


Fig. 3. Student's gaming history in Gantt chart format.

manner, and in the latter rounds of gaming, he will disappear completely.

This game operates in a round-based manner (consisting of eight rounds of gaming, 1 hour per round), and in an accelerated mode (every round equates to six months in the virtual world). In each round of gaming, players have to formulate and implement various investment and operational strategies to yield both quality and abundant farm products for making a profit (the financial gain) in the market. Besides, 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 just-in-time actions (such as cultivating crops and reaping crops at appropriate time).

In spite of the competition for the financial gain, the richest may not be the final winner. Players' final reputation in the virtual world is another crucial judging criterion. This reputation is governed by good public policies and determined by players' practice in sustainable development and environmental protection. Apart from that, as in real life, hard work does not guarantee rewards, 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. However, by setting a range of precautionary measures, “skilled” players can often minimize their loss in unfavorable situations.

### 3.2 Teacher Console

One of the key functions of the teacher console is to assist teachers in preparing and conducting debriefing lessons (Phase 3 of VISOLE). When students are running their farm in the virtual world, the game server *records* their every single gaming action. Teachers can access all students' gaming histories through the teacher console. The console interface presents the histories in Gantt chart format (see Fig. 3). Every rectangular block in a Gantt chart represents the proceedings of a student in a particular time slot with respect to the wind speed, temperature, and rainfall in the virtual world. By clicking the block, teachers can *replay* the proceedings in the form of video playback. This function is termed as *record-and-replay* function of the teacher console [24].

With the record-and-replay function, teachers can look for and extract interesting, problematic, or critical scenarios taking place in the virtual world to conduct case studies with their students. Since all these scenarios come from

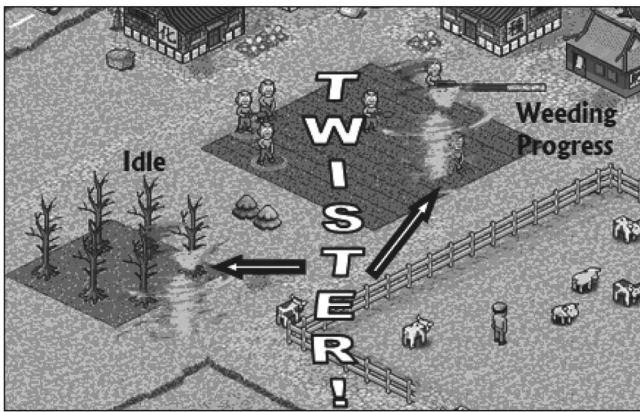


Fig. 4. Twister happens in the virtual world.

students' actual gaming experiences, it is expected that students will be more motivated to explore, 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* [30] based on those extracted scenarios. Therefore, they 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, before each round of gaming, teachers can also use the teacher console to inject *artificial catastrophes* into the virtual world. Situating players in these artificial catastrophes provides them with opportunities to sharpen their ability to deal with contingency and emergency. Fig. 4 shows how an artificial twister happens in a player's farm which has been injected by a teacher.

### 3.3 Knowledge Manual

In parallel with the development of the game and the teacher console, a *knowledge manual* was developed to support Phase 1 and Phase 2 of VISOLE. It covers comprehensively all underlying knowledge employed to model the game. This manual serves two purposes. First, it is a reference guide for teachers to prepare and frame their scaffolding lessons during Phase 1 of VISOLE for equipping students with the required high-level abstract knowledge. Second, it is a learning resource bank for students to look up when they meet some insolvable problems or difficulties arising in the virtual world during Phase 2 of VISOLE.

An electronic version of the manual is put online so that both students and teachers can access it conveniently. The interface of the manual (see Fig. 5) consists of two navigation menus. The horizontal menu is used for navigating the content between the eight knowledge domains (from left to right: *natural environment, biology, government, economics, technology, production systems, natural hazards, and environmental problems*.) The vertical menu is used for navigating the subtopics within a knowledge domain. For example, the content shown in Fig. 5 belongs to the domain of natural environment, and the subtopics therein are *earth's atmosphere, water, and soil*.

### 3.4 Blogging Platform

Phase 3 of VISOLE requires students to reflect on their gaming experiences in both formative and summative



Fig. 5. Knowledge manual.

manners. Farmtasia engages players in reflection exercises through blogging.

After each round of gaming, players are required to "blog" their own reflective journal formatively. Fig. 6 shows the interface of the blogging platform. This platform provides players with a journal template (i.e., "hard scaffolds" [31]) for helping them write their reflection more meaningfully. The template is composed of a set of open-ended guiding questions developed based on Heinich et al. [21] "4D" debriefing approach. The questions include

1. How did you feel while playing this round of gaming? (*Decompressing - feelings.*)
2. What happened in this round? (*Describing - facts.*)
3. How do you compare the happenings in this round to the real world? (*Drawing comparison - enhancing transfer.*)
4. What will you do differently in the coming round? (*Deriving lessons - application.*)

Through the blogging platform, everyone can view and reply to others' blogs. Moreover, by reading students' blogs,



Fig. 6. Blogging platform.

teachers can grasp more clues about each student's gaming/learning progress. These clues can assist teachers in selecting and extracting more critical debriefing content (students' gaming proceedings) to conduct case studies with their students.

Upon the completion of the game, each player needs to publish a summative report on their own blog. This report is not an ordinary report that requires only a summary of what players have experienced in the game, instead, each of them needs to give a proposal to help a fictitious character, "Mr. Lam" who is running a farm in Panyu, the Guangdong province of China. However, Mr. Lam's farm is about to close down due to his poor management. This proposal should provide him with suggestions on how to operate a farm successfully.

## 4 DESIGN OF THE EVALUATIVE STUDY

The primary objective of the evaluative study was, through Farmtasia, to investigate whether VISOLE could "yield" the new constructivist game-based learning opportunities for students as proposed in its original design. Farmtasia, as elaborated in Section 3, was designed for teaching the topic of Agriculture in the senior secondary Geography curriculum HKCEE. However, this study was carried out in the form of an extra-curricular activity, rather than a school curricular learning and teaching activity. This decision was due to the fact that, at that time (even today), VISOLE was a rather new pedagogical idea to the education community in Hong Kong (even to other places in the world). It was difficult to get schools and teachers to "risk" implementing VISOLE in the HKCEE subject.<sup>1</sup>

### 4.1 Participants

In late August 2006, all secondary schools in Hong Kong were invited to participate in evaluating the educational realization of VISOLE by allowing their teachers and students to join a competition, namely, "VISOLE Competition: Farmtasia." To join the competition, each school was required to have

1. two teachers (preferably one senior secondary geography teacher, and one computer teacher) to implement VISOLE and coordinate the competition-related activities and
2. 16 secondary-4 students to participate in the competition.

Eventually, 16 secondary schools joined the competition which took place from mid-October to mid-December 2006. It involved 28 teachers<sup>2</sup> and 254<sup>3</sup> students from the 16 participating schools (School 1 to School 16).

### 4.2 Teacher Enablement Training

Three weeks before the competition started, all teacher participants were required to attend an enablement training

1. HKCEE is an important public examination in Hong Kong secondary education, equivalent to O-level examination in the United Kingdom.

2. Among 16 schools, 10 of them had two teachers, one school had three teachers, and five schools had only one teacher to participate in the study.

3. One of the schools had only 14 students participating in the competition.

to get familiarized with VISOLE (the ideas of scaffolding, game-based situated learning, students' reflective writing, and debriefing), and the technical operation of the game and teacher console of Farmtasia. Besides, every teacher was given a set of scaffolding materials which included scaffolding videos<sup>4</sup> and visual aids with regard to the eight subject knowledge concerned. These materials aimed at assisting the teachers in conducting the required scaffolding tasks in Phase 1 of VISOLE. Apart from that, some examples of debriefing lessons<sup>5</sup> in video format were also provided as references for the teachers to conduct the required debriefing tasks in Phase 3 of VISOLE.

In a week after the training, the teachers were required to "act as students" to participate in a four-round trial competition in the Farmtasia game so as to familiarize themselves with its operation further.

### 4.3 Competition

The competition was composed of two stages. The first stage was conducted on an *intraschool* basis, while the second stage was on an *interschool* basis. In the first stage, each of the 16 schools was required to implement the full VISOLE approach independently. At the end of this stage, four winners from each school then entered the second stage of the competition. In the second stage, all 64 (4 × 16) first-stage winners were grouped randomly in an interschool fashion to form 16 intracompetitive groups, and then competed in the game again. After two bouts, four final winners came out at the end of this stage.

### 4.4 Research Procedures

All research manipulation of the study was carried out in each participating school individually in the first stage of the competition (the part of the VISOLE implementation). The whole research process was divided into three substages, namely *Pre-VISOLE*, *In-VISOLE*, and *Post-VISOLE*, as shown in Fig. 7 diagrammatically.

**Pre-VISOLE** (the upper part of Fig. 7). A student knowledge pretest had been administered one week before the VISOLE process began. The students were allowed to use 35 minutes to complete the test. There were 42 questions in the test, including

1. 25 multiple-choice questions for assessing the students' prior knowledge corresponding to the eight subject areas covered in Farmtasia;
2. 15 true or false questions for assessing their prior knowledge in the application of the eight subject areas in a multidisciplinary manner; and
3. two open-ended short questions for assessing their prior knowledge in the application of the eight subject areas in a multidisciplinary manner.

**In-VISOLE** (the middle part of Fig. 7). In each school, the teachers formed a facilitation team to facilitate the full

4. The scaffolding videos were produced purposefully for this evaluative study. The teacher who presented the scaffolding materials in the videos is one of the instructional designers of Farmtasia (a former member in our research group).

5. The debriefing-lesson videos were recorded during a pilot run of VISOLE in a secondary school carried out in April 2006. The teacher who conducted the debriefing lessons in the videos is one of the instructional designers of Farmtasia (a former member in our research group).

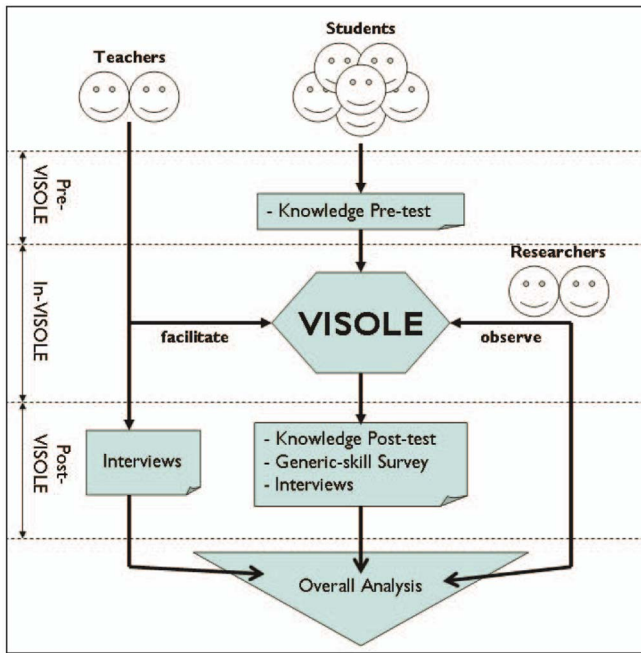


Fig. 7. Research procedures.

VISOLE process (as described in Section 2). This substage took around four weeks to complete, involving four scaffolding lessons (in Phase 1), one gaming preparation lesson (before the start of Phase 2), eight rounds of gaming (in Phase 2), and four debriefing lessons (in Phase 3). Each lesson took 30 minutes.<sup>6</sup> Table 1 shows a summary of the setting. In each scaffolding lesson, the students were equipped with two (out of eight) areas of the preliminary high-level abstract knowledge. The gaming preparation lesson was to familiarize the students with the operation of the Farmtasia game.<sup>7</sup> The four debriefing lessons were held after rounds two, four, six, and eight, respectively. Each round of gaming took 1 hour to finish, and the students were required to play 1 round every two days at home. The researchers (the first and the second authors of this paper) made observations on the scaffolding and debriefing lessons. However, since every school implemented the VISOLE approach in parallel with others, the researchers could only afford to observe one scaffolding class and/or one debriefing lesson in each school.

**Post-VISOLE** (the lower part of Fig. 7). Within one week after the VISOLE process:

1. A student knowledge posttest, which was at the same level of difficulty<sup>8</sup> as the knowledge pretest, was administered. The students were allowed to use 35 minutes to complete the test.
2. A student self-evaluated generic-skill enhancement questionnaire, which was designed by Bennett et al.

6. It aimed at fitting the lessons into the existing lesson time slots in the schools.

7. It included 1) distributing the game manual to the students, 2) briefing them on downloading and installing the JAVA runtime, as well as operating the Farmtasia game, and 3) letting them try a practising round of the game.

8. The format and number of questions of the knowledge posttest were same as the knowledge pretest. The questions appearing in the posttest were rephrased (or reworded) and reordered from those in the pretest.

TABLE 1  
Setting of the VISOLE Process

<b>Scaffolding lesson</b> (Phase 1 of VISOLE)	4 lessons
<b>Gaming preparation lesson</b> (Before Phase 2 of VISOLE)	1 lesson
<b>Gaming round</b> (Phase 2 of VISOLE)	8 rounds
<b>Debriefing lesson</b> (Phase 3 of VISOLE)	4 lessons

[32], was administered. This questionnaire contained 35 question items which fell into four dimensions (*self, information, others, and task*) of generic skills for problem solving. The students were given 20 minutes to self-evaluate the extent of the enhancement of their generic skills for problems solving after the VISOLE process. A five-point Likert scale (5: Very Great; 4: Great; 3: Moderate; 2: Little; 1: No) was adopted in the questionnaire. Appendix A shows the question items with respect to the four dimensions.

3. A number of student and teacher interviews<sup>9</sup> were conducted for gaining more understanding of their learning and facilitation process in VISOLE respectively. Each interview took around 30 minutes to complete.

## 5 FINDINGS

This section delineates first the quantitative findings of the evaluative study, in terms of the students' advancement in the multidisciplinary subject knowledge and enhancement on their generic skills for problem solving after the VISOLE process. Afterward, the qualitative findings of the impending phenomena (emerging during the students' learning process in VISOLE), and the new interventions (initiated or suggested by the teachers to mitigate these impending phenomena) will be discussed.

### 5.1 Knowledge Advancement

The findings discussed in this section were derived from the results of the knowledge pre- and posttests.

The returning rates of the pre- and posttests were 94.1 percent (239 [returned]/254 [delivered]) and 90.6 percent (230 [returned]/254 [delivered]), respectively. The mean scores of the pre- and posttests were 56.5 (out of 100) and 67.5 (out of 100), respectively, with an increase of 19.5 percent. A paired T-test was adopted to compare between the mean scores of the pre- and posttests. Table 2 shows the test result (the p-value is displayed in the right-most column). The result revealed that the students' advancement in the knowledge concerned was significant statistically (p-value < 0.001).

### 5.2 Generic-Skill Enhancement

The findings discussed in this section were derived from the results of the generic-skill enhancement survey [32].

9. The students were interviewed in groups, while the teachers were interviewed individually. All interviews were audio-recorded, and later transcribed into text for qualitative analysis.

**TABLE 2**  
T-test against Pre- and Posttests

	Paired Differences					t	df	Sig. (2-tail ed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
PreTest - PostTest	-10.480	6.565	1.313	-13.190	-7.770	-7.982	24	.000

**TABLE 3**  
Students' Self-Evaluated Generic-Skill Enhancement

Dimension	Mean	Std. Dev
Self	3.39	0.70
Information	3.31	0.78
Others	3.38	0.82
Task	3.43	0.79

The questionnaire returning rate of the survey was 88.6 percent (225 [returned]/254 [delivered]). The results revealed that the students perceived their problem-solving generic skills were enhanced moderately. Table 3 shows a summary of the results in terms of the four generic-skill dimensions, ranging from the mean score of 3.31 (the information dimension) to 3.43 (the task dimension).

**5.3 Impeding Phenomena**

As mentioned in Section 4, qualitative means of inquiry (lesson observations, as well as student and teacher interviews) were adopted for gaining more understanding of the students' learning and teachers' facilitation process in VISOLE. The collected qualitative data were analyzed with Maxwell's qualitative data analysis approach [33] (*which interweaves coding, categorizing, memorizing, and contextualizing*) supplemented with Creswell's thematic development technique of *theme layering*, and *theme interrelating* [34].

According to the analysis, there were some phenomena, which emerged during the VISOLE process, impeding the students' learning process. A number of "plausible factors"<sup>10</sup> leading to these impeding phenomena were identified. They included

1. *students' prior gaming experiences,*
2. *students' interest in gaming,*
3. *students' conception of learning,*
4. *technical efficacy of the game system,*
5. *teachers' time sufficiency for facilitating the VISOLE process, and*
6. *teachers' prior gaming experiences.*

Tables 4a and 4b shows 1) the instances of these impeding phenomena (in the right column), and 2) the corresponding plausible leading factors (in the left column). The term "nongamer students" (mentioned in Factor A1) refers students who have no or very few

10. Notwithstanding the fact that the category construction of the factors was grounded upon the qualitative data with a "bottom-up" approach, the qualitative data per se had yet to be rich enough to give *thick description* [35] of the "inner workings" of the students' learning process in VISOLE.

**TABLE 4a**  
Impeding Phenomena and the Corresponding Leading Factors

Factor		Instance(s) of Impeding Phenomena
A. Students' prior gaming experiences	A1. Students' lack of gaming experiences	<ul style="list-style-type: none"> <li>◆ Some students (non-gamer students) found the game was very difficult to play.</li> <li>◆ They reported that the game's context and operation were too complicated.</li> </ul>
	A2. Students with rich gaming experiences	<ul style="list-style-type: none"> <li>◆ After the first few rounds, some students (gamer students) found the game was boring.</li> <li>◆ They claimed that the game was less exciting than the recreational games they often played.</li> </ul>
B. Students' interest in gaming	B1. Students' lack of interest in gaming	<ul style="list-style-type: none"> <li>◆ Some students were not interested in gaming.</li> <li>◆ In the practising round, they just logged on the game for the sake of "entertaining" their teachers.</li> <li>◆ They did not play the game at home as required.</li> </ul>
C. Students' conception of learning	Students' doubt about the need of "learning through gaming"	<ul style="list-style-type: none"> <li>◆ Some students hesitated about whether "learning through gaming" could really help them learn better.</li> <li>◆ They were unwilling to devote too much time and effort to participate in the VISOLE activity.</li> </ul>
	C2. Students' academic performance-orientedness	<ul style="list-style-type: none"> <li>◆ Some academic performance-oriented students were unwilling to devote too much time and effort to participate in the VISOLE activity.</li> <li>◆ They believed that their participation in the VISOLE activity would not contribute to their academic performance (which is often determined by examination scores).</li> <li>◆ They did not have the motive to conduct the VISOLE-related learning tasks (e.g., gaming, reflective writing, etc.).</li> </ul>
	C3. Students' typical attributions for success and failure of learning	<ul style="list-style-type: none"> <li>◆ Some students interpreted their ongoing failure in the game as a serious negative judgment on their learning participation.</li> <li>◆ Hard work might not yield good gaming results. Not all students were psychologically ready for this, especially for the non-gamer students.</li> </ul>

gaming experiences, while "gamer students" (mentioned in Factor A2) refers to students who have rich gaming experiences. Factors D2, E1, F2 related to the impeding phenomena emerging in the teachers' facilitation process. However, these phenomena influenced the students' learning process implicitly.

**5.4 New Teacher Interventions**

On the teacher side, some of the teachers also observed the same impeding phenomena (mentioned in Tables 4a and 4b) during their VISOLE facilitation process. A number of them

TABLE 4b  
Impeding Phenomena and the Corresponding Leading Factors

D. Technical efficacy of the game system	D1. Exploits <sup>11</sup> of the game	<ul style="list-style-type: none"> <li>◆ Some gamer students headed and finally won the game, as they were able to formulate “degenerate strategies<sup>12</sup>” to play the game. It was not merely due to their understanding of the knowledge underpinning the game.</li> <li>◆ Students’ anger: Some non-gamer students complained that the ongoing and final gaming results were unfair.</li> <li>◆ Students’ frustration: No matter how hard they studied the related learning materials, they were still unable to get better results than the gamer students.</li> </ul>
	D2. Inability of the gaming results to serve as a precise reference for evaluating students’ learning progress / outcomes	<ul style="list-style-type: none"> <li>◆ Some teachers reported that it was difficult to evaluate their students’ formative and summative learning progress merely based on the students’ ongoing and final scoring in the game.</li> <li>◆ The final gaming results might not be able to reflect precisely the students’ learning outcomes (according to the students’ knowledge post-test results).</li> <li>◆ It was not easy for the teachers to be aware of when to give just-in-time assistance or guidance to the students in their learning process.</li> </ul>
E. Teachers’ time sufficiency for facilitating the VISOLE process	E1. Insufficient time for teachers to review the students’ gaming proceedings	<ul style="list-style-type: none"> <li>◆ Many teachers reported that they did not have sufficient time to review all students’ gaming proceedings (through the teacher console), prepare and extract worthy gaming scenarios for conducting case studies with their students in the debriefing lessons.</li> <li>◆ Some teachers suggested that the teacher console should contain some sort of “intelligence:” <ul style="list-style-type: none"> <li>➔ The console should be able to analyze students’ gaming data automatically, and then re-rendering a set of possible case-study scenarios.</li> <li>➔ The teachers could then adopt these scenarios directly for conducting their debriefing lessons.</li> </ul> </li> </ul>
F. Teachers’ prior gaming experiences	F1 Teachers’ lack of prior gaming experiences	<ul style="list-style-type: none"> <li>◆ Some teachers lacking prior gaming experiences had difficulties in answering students’ technical gaming enquiries.</li> <li>◆ These teachers were unable to help the non-gamer students begin Phase 2 of VISOLE effectively.</li> </ul>

new interventions were not specified in the original design of VISOLE. They included

1. inviting gamer students as game tutors,
2. using an alternative strategy to select case study scenarios for conducting debriefing lessons,
3. triangulating students’ learning progress with other evidence,
4. timely encouragement and counseling,
5. fostering students’ off-the-game collaborative sharing, and
6. relating students’ participation in VISOLE to their academic performance.

Tables 5a and 5b shows 1) the interventions (in the first column) and 2) their descriptions (in the third column), as well as 3) the corresponding impeding phenomena that the teachers aimed at targeting on (in the second column). In this table, the notations utilized to denote the impeding phenomena (in the second column) align with the ones in Tables 4a and 4b.

## 6 CONCLUSION AND DISCUSSIONS

There has been a worry that, in game-based learning, students may not learn anything more than clicking a number of buttons to receive desired gaming outcomes [37]. Moreover, students often have difficulties in making connections between a game and the referent real-world system that the game is intended to represent [38]. Although they are sometimes requested to reflect on their “game-based learning” experience, not everyone is able to do it well equally [39].

Mishra and Foster [40] argued that although the educational potential of “learning through gaming” 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 attempt to address this issue by proposing VISOLE. It is a three-phase constructivist pedagogical approach to empower game-based learning. The importance of teachers’ roles is emphasized therein.

Evidenced by the quantitative part of the evaluative study discussed in this paper, in general, VISOLE could provide the students with opportunities for acquiring the multidisciplinary subject knowledge and enhancing their generic skills for problem solving. However, we admitted that there were a number of weaknesses in the research setting, including the nonnaturalistic learning and teaching context, the students’ distraction caused by the competition, the sampling problem (on both student and teacher sides), and the self-reported nature of the questionnaire about the generic-skill enhancement.

VISOLE has yet to be “perfect.” Revealed by the qualitative part of the study, there were some phenomena, which emerged during the VISOLE process, impeding the students’ learning process. Nevertheless, a number of the teachers initiated or suggested some new interventions to mitigate these phenomena. The preliminary identification of these impeding phenomena and new interventions could throw light on how to enhance the current design of

initiated or suggested some new interventions that were targeted on mitigating these impeding phenomena. These



TABLE 5a  
Teachers' Initiated/Suggested Interventions

Teacher Intervention	Impeding Phenomena Being Targeted (See Table 4)	Description
U. Inviting gamer students as game tutors	A1, F1	<ul style="list-style-type: none"> <li>Some teachers invited the gamer students to be "game tutors" to help the non-gamer students start up the gaming at the beginning stage of Phase 2 of VISOLE.</li> </ul>
V. Using an alternative strategy to select case study scenarios for conducting debriefing lessons	E1	<p><b>At School 15:</b></p> <ul style="list-style-type: none"> <li>Before a debriefing lesson, based on the students' current gaming results and blog contents, the teacher targeted on several students whose gaming proceedings might be worthy to be used for conducting case studies.</li> <li>At the beginning of the lesson, the teacher asked those students to present what they had conducted in the "virtual world," and the happenings therein.</li> <li>Based on the students' presentations, the teacher tried to identify some problematic gaming scenarios and made use of the teacher console to replay those scenarios to conduct case studies with their students.</li> </ul>
W. Triangulating students' learning progress with other evidence	D2, E1	<ul style="list-style-type: none"> <li>Instead of solely relying on the students' ongoing gaming results, or reviewing all students' gaming proceedings, some teachers also evaluated their students' learning progress with their blogs and performance in the debriefing lessons.</li> </ul>
X. Timely encouragement and counseling	C3, D1	<ul style="list-style-type: none"> <li>Some teachers gave timely encouragement and counseling to the students once noticing any signs of negative emotion (e.g., frustration, anger, etc.) among the students during the VISOLE process.</li> <li>Teachers' timely encouragement and counseling were given to the students in the debriefing lessons, off the lessons, or through replying to the students' blogs.</li> </ul>

TABLE 5b  
Teachers' Initiated/Suggested Interventions

Y. Fostering students' off-the-game collaborative sharing	A1, A2, B1, C1, F1	<p><b>Suggested by the teachers of School 2 and School 8:</b></p> <ul style="list-style-type: none"> <li>Instead of leading every debriefing lesson themselves, some teachers suggested setting up student collaborative groups so that students can share their gaming / learning experience in the VISOLE activity in some debriefing lessons.</li> <li>Students in groups can discuss what mistakes they have made so far, and evaluate alternative courses of action among themselves.</li> <li>It is better to arrange students with more diverse background into a group. For example, a combination of non-gamer students and gamer students, or students with strong interest in gaming and students with no interest in gaming.</li> </ul>
Z. Relating students' participation in VISOLE to their academic performance	B1, C2	<p><b>At School 16:</b></p> <ul style="list-style-type: none"> <li>The students' participation (but regardless of their gaming results) in VISOLE was taken into account in evaluating their annual performance in extra-curricular participation of the school year. The rating of that performance was shown in each student's annual study report.</li> </ul> <p><b>Suggested by the teachers of School 1, 3, and 9:</b></p> <ul style="list-style-type: none"> <li>The students' participation (but regardless of their gaming results) in VISOLE contributes to a portion of their continuous assessment in the subject of Geography.</li> </ul>

VISOLE. For example, the infusion of "game operation skill scaffolding" and "emotional debriefing" respectively into Phase 1 and Phase 3 is a sort of plausibly desirable enhancement.

Novice learners, like construction workers, need structures of temporary support to build things up [41]. Scaffolding [28] refers to a process by which a more knowledgeable peer assists ones so that they can perform tasks that would otherwise be out of reach. In VISOLE, the

scaffolding exercise focuses only on equipping students with preliminary high-level abstract knowledge, without emphasis on preparing them to begin their gaming technically. In the study, although a "practising round" was provided for the students to get themselves familiarized with the Farmtasia game, this kind of self-directed practice was not working for everyone (see Tables 4a and 4b, Factor A1). It is recommended that Phase 1 of VISOLE needs to be composed of two parts. The former part is still "multidisciplinary scaffolding." The latter part would be "game operation skill scaffolding" which assists students (especially nongamer students) in starting up their gaming. Furthermore, the latter part is not necessary to be carried out by teachers, but gamer students (see Tables 5a and 5b, Teacher Intervention U).

Players hate to lose; they are even willing to "cheat" in gaming by using degenerate strategies [42]. In the study, the unfairness stemming from the "cheats" in the Farmtasia game irritated some students (see Tables 4a and 4b, Factor

D1). In VISOLE, the debriefing exercise focuses only on students' cognitive aspect, without paying attention to their emotions emerging during the course of gaming. It is recommended that, in Phase 3 of VISOLE, besides monitoring the progress of students' development of the virtual world, teachers also need to be more aware of students' emotions when reviewing their reflective journals and conducting debriefing lessons. "Emotional debriefing" should be carried out whenever necessary (see Tables 5a and 5b, Teacher Intervention X).

Assessment in VISOLE is another issue that needs to be addressed (see Tables 4a and 4b, Factor C2). Assessment is a sort of important learning feedback for students [39]. Nonetheless, assessing students' learning outcomes in game-based learning is not easy. Relying on students' gaming results to assess their performance may trigger the issue of assessment unfairness (see Tables 4a and 4b, Factors D1, D2). Assessing students' learning performance through reviewing their gaming proceedings sounds more authentic; however, it is impractical (see Tables 4a and 4b, Factor E1). Using students' formative and summative reflective writing as a basis for assessment seems more practical; nevertheless, it may disadvantage the ones who are bad in language or hate writing. Therefore, assessment in VISOLE is an important topic that needs further research effort.

## 7 FURTHER STUDY

Punch [43] argued that too much research has tried to go directly to measurement and quantitative mapping, without the fuller understanding of the process and phenomena emerging therein. Undoubtedly, "classical" controlled comparative studies have their value in highlighting the differences among game-based learning, conventional classroom teaching, and other more mature constructivist learning approaches. However, this kind of comparison will become more meaningful and significant only when a more established pedagogical framework for game-based learning appears in the domain.

Formulating pragmatic integration of games into education requires researchers and educators to reflect on what, when, how, and why students learn (or do not learn) in the process of gaming [37]. In this paper, we discuss some initial understanding of students' learning process in VISOLE. However, it has yet to be considerably "in-depth." In the study, the scaffolding and debriefing lesson observations were not conducted thoroughly enough to carry out triangulation [44] and thick description [35] during the qualitative analysis. Apart from that, as elaborated in Section 4, this study was conducted in the competition context. In other words, what happens when VISOLE enters a "real" classroom is still unknown. Thus, it opened up the need of further research on gaining an in-depth understanding of the "inner-workings" of students' learning process in VISOLE in authentic classroom context. The findings will shed light on the further enhancement of VISOLE, and provide insights into the integration of constructivist game-based learning into school education.

## APPENDIX A

### STUDENT GENERIC-SKILL ENHANCEMENT QUESTIONNAIRE: GENERIC-SKILL DIMENSIONS AND QUESTION ITEMS [32]

<b>Self</b>	<ol style="list-style-type: none"> <li>1. Management time effectively</li> <li>2. Set objectives, priorities and standards</li> <li>3. Take responsibility for own learning</li> <li>4. Listen actively with purpose</li> <li>5. Using a range of academic skills</li> <li>6. Develop and adapt learning strategies</li> <li>7. Show intellectual flexibility</li> <li>8. Use learning in new or different situations</li> <li>9. Plan/work towards long-term goals</li> <li>10. Purposefully reflect on own learning</li> <li>11. Clarify with criticism constructively</li> <li>12. Cope with stress</li> </ol>
<b>Information</b>	<ol style="list-style-type: none"> <li>13. Use appropriate sources of information</li> <li>14. Use appropriate technologies</li> <li>15. Use appropriate media</li> <li>16. Handle large amounts of information</li> <li>17. Use appropriate language and form</li> <li>18. Interpret a variety of information forms</li> <li>19. Present information competently</li> <li>20. Respond to different purposes/context and audiences</li> <li>21. Use information critically</li> <li>22. Use information in innovative and creative ways</li> </ol>
<b>Others</b>	<ol style="list-style-type: none"> <li>23. Carry out agreed tasks</li> <li>24. Respect the views and values of others</li> <li>25. Work productively in a cooperative context</li> <li>26. Adapt to the needs of the group</li> <li>27. Defend/justify views and actions</li> <li>28. Assist/support others in learning</li> </ol>
<b>Task</b>	<ol style="list-style-type: none"> <li>29. Identify key features</li> <li>30. Conceptualise ideas</li> <li>31. Set and maintain priorities</li> <li>32. Identify strategic options</li> <li>33. Plan/implement a course of action</li> <li>34. Organise sub-tasks</li> <li>35. Use and develop appropriate strategies</li> </ol>

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