Chapter 11
Problem Solving Processes and Strategies in the Virtual Interactive Student-Oriented Learning Environment

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EXECUTIVE SUMMARY

With the integrated use of quantitative and qualitative research methods, this chapter describes the learners' problem-solving processes and the strategies they used under a pedagogy called Virtual Interactive Student-Oriented Learning Environment (abbreviated as VISOLE). By recording learners' operations in the game, and collecting their game logs (BLOG), summary reports, and interview records, also based on the observations done by the researchers, it is found that the problem solving strategies that learners used in VISOLE primarily included: (1) trial and error, (2) random, (3) purpose-oriented, (4) starting from simple, (5) adventure, (6) comprehensive, (7) focused, (8) index, (9) BUG, (10) entertainment strategies, etc.

DOI: 10.4018/978-1-4666-1933-3.ch011

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INTRODUCTION

Constructionists have been putting forward theories and proposals in different prospects for a long time for education revolution, and in those proposals, a basic theory has been widely adopted: study with high-level thinking and construct knowledge based on problem solving (Zhang, 2000). However, while we have problems every day, what on earth is a problem and what is problem solving? Actually, the definition of "problem" is not complicated, for example, Robertson (2001) stated that, when a person wants to do something but does not know how, that is a problem. As for problem solving, Anderson (1980) regarded it as a cognitive action towards a given goal. In short, when people want to achieve a goal but do not know how, a problem emerges, and the thinking process through which people use comprehensive knowledge and skills to achieve the goal is called problem solving.

Problem solving ability is vital to a person's learning, working and living experiences, and therefore Hong Kong Curriculum Development Council (2001) listed such ability as one of the nine students' generic abilities that need to be develop. As for how to develop problem solving ability, many constructionists (e.g., CTGV, 1990) suggest the use of a real or a nearly real task environment for learners to solve problems there so that they can develop their problem solving abilities through solving real problems. The rapid development of online games has brought about new inspiration to educators since games would involve environments with challenges in which players need to consult and integrate all kinds of information in order to solve problems there, so that they can win the games. Therefore, many researchers think that a more attractive learning environment can be created based on games to encourage learners to solve problems more actively on their own initiative in order to improve their problem-solving ability and other advanced abilities (Whitebread, 1997; Wang, Hsiao, & Yu, 2006).

Lee and Lee (2001) proposed a learning model called Virtual Interactive Student-Oriented Learning Environment (VISOLE hereinafter). VISOLE is a learning model that allows students to learn knowledge by themselves in a virtual game-based environment and through interacting with the others. The VISOLE process involves three phases: (1) scaffolding learning phase, in which students were taught the high level knowledge including the topics to be involved and how they are related, and also ways to locate the required knowledge; (2) game based learning phase, in which students role played in the virtual world specially created for this purpose and learn by making decisions; and (3) reviewing and summarizing phase, in which students reviewed and summarized their performances under the guidance of teachers. Although Phase 2 and 3 are defined separately, in actual implementation, they are partly overlapped. Based on the framework of the VISOLE learning model, the Centre developed an educational game titled *Farmtasia* (Figure 1). The game cre-

Figure 1. Main scenario of farm fantasy

ated a virtual near-real farm, in which learners are expected to act as farm owners to which was aimed to help learners to learn knowledge of agriculture and geography and to develop their generic abilities like problem solving and decision-making.

RESEARCH METHOD

The present study aimed to study: 1) how a learner solved problems in the game environment; 2) what strategies the learner adopted in the problem solving process. 254 fourth grade students from a Hong Kong middle school were invited to participate.

Learning Processes

The students were required to go through a learning process which can be roughly divided into three phases corresponding to the VISOLE model. The scaffolding learning phase took five days, during which around one hour was dedicated to learning every day. The game based learning phase took 16 days, during which a round of competition was held every other day, every round took about an hour to simulate half a year in reality. Besides gaming, students were required to write game logs after each a round in order to help them to review what they have done in that particular round. The teachers would also comment on their reviews. The last step in the learning process is the review and summary phase, which took about 4 days. In this stage, the teachers organized two review and summary meetings to help students to reflect and write their summary reports.

Data Collection and Analysis

The game Environment provides a "Replay" function (Shang, Lee, Lee, Wong, Luk, & Cheung, 2006), which works as a recorder to record all the operations done by the players. Through the use of this function, the actual operations of the learners in the game could be reviewed and the playing experiences of the learners could be played back like video clips.

In addition, learners are required to write their game logs and summary reports during their learning processes. The researchers also interview the students and teachers, and also observe their classrooms. All these data contributed to the study of their problem solving processes and strategies in the gaming environment.

A large quantity of data was collected in this research experiment. First of all, 8 rounds (about 8 hours) of game operations of every student were collected by using the "Replay" function (Shang, et al., 2006); in addition, the game logs and summary reports created by the students and the interview records were also collected.

Students' problem solving processes and their strategies were then identified from the game logs and summary reports created by the students, and also the interview records done by the researchers. With these data, students' problems encountered and their ways to overcome them were analyzed. The following section reports the results found.

PROBLEM SOLVING PROCESSES IN THE VISOLE

Students encountered many problems in the game, including visible and invisible problems, well-structured and ill-structured problems. In this section a number of typical problems and the students' ways to handles will be reported.

How to Handle Major Difficulties

The present study was focused at identifying the difficulties the students experienced and how they overcame. Difficulties experienced included those caused by disasters, financial difficulties, and death of crops, insect pests and epidemic diseases. The following paragraphs describe what these are and how the students handled them.

Disasters

In the replay of the gaming experiences, it was found that a student did well in the first four rounds and took the leading place. During that period, his excitement was reflected in his BLOG. However, due to a game system error, he could not enter

the game in the fifth round and suffered serious loss. Though he still occupied the leading place in his team, his competitive edge was no longer prominent and he kept worrying that "*I may lose after all the victories!*" It was more unfortunate for him that a fire occurred in the eighth round of the game. It was a heavy blow to him and it could be seen in his blog that he was basically desperate:

This sudden unexpected fire reduced my cash savings enormously, I'm devastated, devastated, devastated...

When he was about to give up, he noticed that the price of apple was going up and therefore placed all his hope on apple trees, he started to "*bend on apple tree care*." In the replay of the round it could also be seen that his garden management was strengthened significantly, for example, the garden was watered 15 times in the eighth round while he only watered the garden 8 times in the sixth round. These data reflected his attention to the fruit tree from one side. It was fortunate that his strategy of focusing on fruit trees was a great success and he won the first place in the team.

Actually most of the students who encountered disasters did just like this student, they re-planted what could be re-planted as quickly as possible and salvaged whatever could be salvaged, in short, they left no stone unturned to handle the disasters.

Financial Difficulties

Every farm was given 30,000 dollars at the beginning of the game and students then needed to make money by running the business. If the students did not perform well in the business operation, they might encounter financial difficulties or even deficits.

In the replay of the game, it is found that a student did not perform well in the business operation at the beginning and his cash flow kept shrinking, at that time he was left with only a little more than 800 dollars. It could be noticed in his blog that he worried a lot about money and kept talking about making money:

Now I don't actually need to buy anything, in short, I need to make money make money make money make money make money.

In the game replay, it could be seen that he was very careful with his wheat, livestock, and fruit trees at that time and his blog showed that he noticed the price of pear rocketed and thus developed a plan to focus on the development of his garden. Then in the fourth round of the game, he strengthened the management of the garden and made more than 120,000 dollars by selling pears, in this way he easily overcame the financial difficulty at one blow.

In fact, many similar circumstances could be seen in the replay of the game. The strategies adopted by the students to handle the financial difficulties could be summarized as "*opening up new sources of income and reducing expenditure*": they focused on the development of certain parts of their farms or sold live stock to make money in order to "*open up new sources of income*," and they cut staff size to save salaries, sold live stock to save the cost of fodder and reduced purchases in order to "reduce expenditure."

Death of Crops

In the replay of the game, we did see many events of crop death and a typical example was the experience of a student planting turnips 5 times. The student had three consecutive failures in turnip planting in the fourth, fifth and sixth rounds of the game because of planting in wrong seasons and insect pests. The three consecutive failures in turnip planting made the student so sad that she gave the title "*My Fate with Turnips*" to her game log of the sixth round and stopped planting turnips ever since.

However, it was noticed in the replay of the game that she started to plant turnips again in May in the seventh round of the game and her blog showed that she did so because she was attracted by the high price of turnips. Nevertheless, she remained a little suspicious of a successful harvest possibly because of her three failures with turnips and she thus entitled her game log of the round "*Fight with Turnips Again*." This time she sowed the seeds in the right season and had fewer insect pests, after careful management of the field, she had a successful harvest of turnips at the end of July in the eighth round of the game. This obviously made her very happy and she sowed turnip seeds again at the beginning of August right after the harvest. After battling 3 insect pests, she had a good harvest of turnips again in October. Naturally, she rejoiced in the two successful harvests after the three consecutive failures and entitled her game log of the eighth round "*Success with Turnips*."

Of course, when we looked at the timing of the sowing, we could see that she actually did not fully master the skills of farm management, but she never got discouraged by the failures and kept trying, thinking and working hard, eventually she overcame the insect pests and succeeded in planting turnips. Her attitude and spirit really deserved encouragement.

Insect Pests

Crops, fruit trees, and livestock in the farms were all subject to possible insect pests and epidemic diseases; however, since the Game Manual gave detailed medical instructions, the insect pests were a well-structured problem and could be solved usually with the right types of medicine.

In the actual game process, it could be seen that most of the students responded quickly to the insect pests and epidemic diseases and tried hard to cure them. Obviously, the cure often failed at the beginning, possibly because the students were unfamiliar with the medicines or did not move quickly enough, but as the game scenarios moved forwards, the success rate of the cure increased gradually, which showed that the students' ability of handling the insect pests and epidemic diseases were growing stronger.

In addition, it should be noticed that, even when the problems to be solved were ill-structured, some of the students still interacted and communicated with others. They also reviewed their operations actively and tried to find out better solutions. For example, a student wrote in his blog that:

I was scared when I had it for the first time and I did not know what to do but pressing the "Pause" button and trying to figure out a way to handle it. When I saw solution recommendations from others, I jumped to them and at last got my land cured, my heart was lightened finally.

In handling this kind of problems, a small number of students had some very innovative and unique ideas. A student harvested his crops right after the outbreak of an insect pest in the hope of reducing the lost to the minimum; while another student would compare the value of the crops and the cost of the medicines before deciding whether the crops should be cured. A further example was that a student ploughed the affected fields and sowed seeds again as soon as insect pest or epidemic broke out. Those strategies might or might not be correct, but it was undeniable that those were quite inventive ideas.

How to Choose Crops

A commonly seen problem during the problem solving processes was the choosing of crops to plant. The decision was not easy since it had to be made based on factors including prices, seasons, growing cycles, crop rotation, and also unexpected events.

As the game allowed students to check out price information conveniently, from the data collected, it can be confirmed that students did frequently use this feature during the game. It could be seen that many students decided which crops

to plant mainly based on the prices. The case of one student is a typical example: he consecutively planted tomato for 6 times just because the price of tomatoes was high, although it was found that he never ran his farm well. The student did know that crop planting should be associated with seasons as shown in his game blog in the third round. However, he still planted cabbage at the end of September in the fourth round just because of the high cabbage price. In addition, it was found that he harvested the cabbages he planted before they were ripe in the sixth round so that he could plant tomatoes as the tomato price went up. Maybe the success with tomato this time reinforced belief on price as the sole determinator, he then planted tomato for further 5 times consecutively regardless of the season and he failed 4 times.

Although price was important and was easily taken into consideration, crops could easily die or turn into poor harvest if they do not consider the sowing season, so most of the students soon realized the sowing season should also be considered carefully. For example, a student said in his blog:

I regretted the most today that I planted the corn when I was attracted by the price, I got only $381 at last ... (I learned that it was the weather only afterwards)

As time passed by, most of the students gradually took more factors into consideration, e.g., prices, seasons, growing cycles, crop rotation, etc. In fact, the researchers analyzed 61 cases of sowing activities based on the combination of game replay and blogs, in which seasons were considered in 34 cases, prices in 24 cases, growing cycles in 10 cases, crop rotation in 2 cases, emergencies in 4 cases, epidemics and insect pests in 2 cases and curiosity towards never-planted plants in 3 cases. In 25 of these cases, i.e., 41.0% of the cases, two or more factors were taken into consideration, and there were only 4 cases of random planting, accounting for 6.6% of the analyzed cases. These data showed from one side that most of the students would consider one or multiple factors before making a decision; and after rounds of crop planting, students would take more and more factors into account.

The case of a student was of much significance in choosing crops. He had thought much about the importance of sowing season, but in the sixth round of the game he still planted onions at the beginning of October, which was not the right season for onions. This puzzled researchers a lot: why did he make the same mistake after thinking so much about it? The answer soon came out from his blog:

I meant to plant wheat in the mid October, but careless as I was I clicked the onion button by mistake and did not find out until seeds sprouted. I did not want to dig them up, so I decided to try it out and see whether they could survive. The answer was—they could not (so sad...)

Thus, researchers were thus aware that VISOLE provided the students with not only an environment for finding problems, analyzing problems and solving problems, but also a research oriented learning environment in which they could develop their hypotheses and test them.

Livestock Trading

The game provides cattle and sheep in the livestock category and students may choose to purchase either one or both while the maximum number of livestock allowed was 10.

In the replay of the game, it can be seen that most of the students adopted an average and conservative strategy at first and gradually expanded the herd size and adjusted the kinds of livestock when they got familiar with the game. A student was typical in this aspect. In the game replay, it could be seen that she bought 2 cattle and 2 sheep at the beginning of the first round of game. As she stated in her blog, she bought only 4 animals because "I thought it would be the most difficult to raise animals, so I was conservative at the beginning." However, it could be noticed that she soon increased her livestock to 4 cattle and 3 sheep by May in the first round and from her blog it was shown that she did it because she found it was not that difficult to raise animals. The game replay also showed that she did enhance the livestock farm management in the last few months of the first round. Therefore, it was concluded that the student enhanced livestock farm management while increasing the herd size and adjusting the livestock types as she grew familiar with the game.

Obviously, there were many other livestock trading strategies, e.g., selling the livestock when the fund was tight; some students just bought livestock at will and others bought them at risk, i.e., bought 10 animals all at once regardless of whether there was enough food to feed them. However, generally most students started with a small herd and adjusted the type and amount of livestock gradually. In fact, we analyzed the game operations of 40 students selected at random, in the first round of the game, 5.1 animals were bought per person on average, including 2.4 cattle and 2.7 sheep. The ratio of cattle to sheep was 8:9, which was close to 1:1. Paired t test of the cattle and sheep amounts showed no significant difference ($P>0.01$), which showed that most of students followed the equal division principle when they did not know which was the good option. In addition, the total amount of the livestock bought showed that most of the student adopted conservative approach when they had not yet learnt enough management skills, that is, they just started with small herds and accumulated experiences. In the eighth round of the game, a student owned 8.2 livestock on average, much higher than the 5.1 of the first round. When we took a further look into the ratio of cattle to sheep, we saw each of the students

owned 3.15 cattle and 5.05 sheep on average, and the ratio of cattle to sheep was therefore 3:5, actually much smaller than the initial 8:9. These data proved again that most of the students were trying hard to learn the livestock farm management skills and they gradually adjusted the livestock types and expanded the herd size.

However, we also found something meaningful or interesting of livestock trading. For instance, a student sold his ox right after the breeding and would buy it back when he needed it again because he regarded this as a way to save money. Although this might not be practical in real life, it was indeed a novel and unique idea. In addition, another student bought a cow at the end of the game, not for the purpose of making money, but because he found "*farm seemed no longer interesting without cattle*."

Some students also showed affection for calves on the farm and even had the feeling of reluctance when they sold the calves. It could be seen that VISOLE also provide deep emotion experiences for students and allowed students to take "emotion" into consideration in the problem-solving processes.

Fruits-to-Leaf Ratio

In the fruit tree management, "*pruning*" and "*fruit thinning*" were needed to keep an appropriate fruit-to-leaf ratio.

In the game replay, we saw that students either rarely pruned the trees and thinned the fruits, or pruned the trees or thinned the fruits at random, e.g., a student pruned the trees for 4 times and thinned the fruits for 5 times in the first 3 months of the first round when the fruit trees had not even sprouted.

As the game developed, most of the students learned the importance of keeping an appropriate fruit-to-leaf ratio and put more efforts into pruning and fruit thinning. However, maybe they paid too much attention to the fruit-to-leaf ratio and neglected the real demands for pruning and fruit thinning, and as a result some student ended up with few fruits while the fruit-to-leaf ratio was appropriate. For example, a student pruned 27 times and thinned fruits 20 times in the second year (including the third and fourth rounds) of the game. Though the fruit-to-leaf ratio in his garden was up to the standard, he harvested only 4 fruits and the number of leaves was just 160, which brought him little income.

As excessive pruning and fruit thinning reduced income, most of the students started to prune and thin fruits with more reasonable attitude, i.e., they not only took into account the fruit-to-leaf ratio, but also actual demands.

We analyzed the game operations of 30 apple tree-planting students chosen at random and we carefully calculated the amount of harvested fruits, the amount of leaves and the fruit-to-leaf ratio in the apple harvest season every year (which includes 2 game rounds). Our result showed that the fruit-to-leaf ratio of the second

year among 4 consecutive years was closest to the standard value, but the amount of harvested fruits and the amount of leaves in the second year were the smallest. However, the fruit-to-leaf ratio in the fourth year of the game was only second best, but the amount of harvested fruits and the amount of leaves were the biggest in the fourth year. Maybe those data were not completely objective, but it showed from an aspect that most of the students gradually took more and more elements into considerable and found comparatively effective way to handle the problem with the fruit-to-leaf ratio.

How to Face BUGs

"BUGs" are usually used to indicate the defects and errors in the software. To some extent, the BUGs in this game had an impact on the enthusiasm of the students; however, in the replay of the game and game blogs, we could also see that some students adopted unexpected approaches towards some of the BUGs.

Speculate in Cattle

On the virtual farm, the selling price of cattle could be higher than the purchase price at some specific time points and a few students used this BUG to make money by purchasing and selling large amounts of cattle and sheep; this was called "speculate in cattle" by students and teachers. Although "*speculating in cattle*" was not encouraged, researchers did admire the explorer ability and creativity of the students who found this phenomenon.

Obviously, those students took a lot of pain to discover this BUG, e.g., a student gave up actively managing the farm since the later period of the fourth round and bent on researching ways to make money; he eventually discovered this method and then spared no efforts to "*speculate in cattle*" in the game rounds that followed, he made so much money that he became the No. 1 in his team.

An interesting thing was that, when he found this method and made a lot of money, he begun to lose interests in the game. We also interviewed other students who speculated in cattle and they all stated that they speculated in cattle just for money, and that cattle speculation did make the game much less interesting.

Save the Progress

The game was designed to temporarily save the operations of the students on local machines to keep an appropriate game speed, but the system conducted the auto-save function every 20 minutes to save the game operations of all students on the game server. If a computer broke down suddenly before the game operations were

saved on the game server, the progress made in the recent 20 minutes would be lost and the affected student had to start all over again.

Obviously, this is a technical disadvantage of the game and it actually made some students very angry. Nevertheless, we found that a student wittily used this BUG to make the time run backwards. He would close the game window immediately after his wheat died and start all over again, and he did this repeatedly in the hope to find the best planting strategy. Of course, this was actually unfair to other students, but we had to admit that this student was good at creatively thinking and had the ability to "turn a bad thing into a good one."

PROBLEM SOLVING STRATEGIES IN VISOLE

How would people think in a psychological predicament? Usually people would divide the whole problem solving process into three steps: find a problem, analyze the problem, and solve the problem. In the problem solving process, generally people could use the algorithms strategy or the heuristics strategy (Zhang, 1996). The analysis in the previous section showed that VISOLE did provide plenty of opportunities for students to find, analyze and solve problem. To sum up, the students generally adopted the following problem solving strategies in the game:

Trial and Error Strategy

"Trial and error strategy" indicates a progressive learning method for "blindly trying and continuously reducing mistakes."

Although the "trial and error learning" theory tends to be mechanical and too simplified, it is a common learning method in daily-life study; and in the game-based learning, choices or inputting is usually made with mouse clicking or keyboard, so it is even easier to adopt the "trial and error learning." That was also the case in this experiment. Students frequently used the "Trial and error strategy" to choose crops and handle epidemics and insect pests, e.g., some students neither read the game manual carefully nor discussed or communicated with other students, but learned the farm management skills only through the "trials and errors" in the game.

Random Strategy

Random strategy indicates operations without any purpose, i.e., operations at random, such as purchasing and selling cattle and sheep at random, choosing fruit trees at random, choosing crops at random, etc., in the game, etc. For example, a student remembered that his worker was still in the warehouse when he harvested onions

in the fourth round of the game, so he ordered the worker to plant the turnip seeds that were happened to be in the hands of the worker and did not consider whether it was suitable to plant turnips.

Purpose-Oriented Strategy

In a broad sense, all strategies except the random strategy are purpose-oriented; however, the purpose-oriented strategy here is defined specifically to indicate operations with particular purposes. For example, apple trees were chosen because apples tasted good, or some students decided to plant wheat in winter because wheat was the only crop that could survive the winters.

Starting-From-Simple Strategy

When a person faces a complicated problem, he usually starts from the simple parts of the problem and solves the problem step by step from the simpler parts to the more complicated parts. That is the starting-from-simple strategy.

Hong Kong students learned about farms in textbooks, but they were not very familiar with farm and it was natural for them to adopt the starting-from-simple strategy to handle such an almost totally alien matter. It was particularly common with the farm management, e.g., a student might buy 2-3 livestock at first in the fear that he could not manage 10 animals, and then accumulated experiences gradually from the simple things first.

Adventure Strategy

Adventure strategy indicates trials at the risk of failure in times when students were not absolutely sure about what they were doing.

Although most of the students adopted the starting-from-simple strategy, a few students took the adventure strategy. For example, a student bought 10 livestock all at once at the beginning of the first round of the game without actually thinking it through.

Comprehensive Strategy

Comprehensive strategy means simultaneous developments in all aspects, e.g., simultaneous farming field, garden, and grazing land developments with great efforts.

A farm was divided into three parts and the developments of different parts were naturally of different levels of priority. In the previous analysis, we saw many students adopted the comprehensive strategy in the hope to obtain the most benefits, e.g.,

a student assigned two workers to his farming field and another two to his garden for non-stop irrigation and fertilization. Meanwhile he also cleaned and grazed his livestock frequently.

Focused Strategy

Compared with the comprehensive strategy, the focused strategy is defined to focus on tasks with different levels attention according to the priorities.

When a farm was facing a major difficulty, the student tended to adopt this strategy to manage the farm, e.g., when a student mentioned in the above section had a fire in the farm and his financial status fell behind others, he started to focus on the garden and turned the situation around by doing so.

In fact, in the game replay we noticed that many students usually adopted the comprehensive strategy at the beginning and adjusted the management focus as the game progressed based on a variety of information and their own management abilities, some students even gave up the grazing land completely and focused solely on the farming fields and gardens.

Index Strategy

The so-called index strategy, refers to the game usually expressed in number of crops, fruit trees and livestock growth, while some students simply manage the farm by adjusting these figures. In the game design, it was relatively difficult to show the growth of corps only by using graphic expressions, so figures were used to indicate the their growth. This kind of design was called the index-based design and it caused some students to manage farms solely by observing these indexes. For example, a student pruned the trees and thinned the fruits extensively and at last the fruit-to-leaf ratio of the fruit trees was identical to the standard ratio, but the number of fruits harvested at last was only 4 while the number of leaves was 160, and the money made out of the fruit trees was just a few hundred dollars.

BUG Strategy

BUG strategy indicates the practice of some students who tried everything to find BUGs in the game in order to learn the tricks for making money.

The most impressive embodiment of the BUG strategy in the game was cattle speculation, e.g., the student mentioned in the previous section bent on looking for the ways to make money since the fourth round of the game and successfully found the “cattle speculation” and made a lot of money.

As far as game design was concerned, it was obvious that BUGs should be reduced to the minimum, but the students adopting this strategy should be recognized to some extent as they actively explored every parts of the game and developed creative solutions to problems, which would naturally help them to cultivate abilities of research and creation. Therefore, this reminded us that we could intentionally set up some "controllable BUGs" in the game to guide and encourage students to explore and create.

Entertainment Strategy

Entertainment strategy indicates carrying out operations without particular purposes, but just for fun.

This strategy was more common in the grazing land management, e.g., a student bought a completely unprofitable ox just for fun, and some students did not sell calves simply because they thought the calves were lovely.

DISCUSSION AND CONCLUSION

The problem solving processes of the students in the VISOLE was analyzed above concerns how they handled major difficulties, chose crops, chose fruit trees, traded livestock, maintained fruit-to-leaf ratio and handled BUGs. It could be seen that VISOLE did provide the students with a lot of opportunities to identify, analyze and solve problems.

It could also be seen that, during the problem solving process, students adopted ten major strategies: (1) trial and error, (2) random, (3) purpose-oriented, (4) starting-from-simple, (5) adventure, (6) comprehensive, (7) focused, (8) index, (9) BUG, and (10) entertainment strategies. Among those strategies, the random strategy was of little significance to the knowledge construction even though it satisfied the demands of students for leisure entertainment, hence the random strategy should not be promoted; the trial and error strategy could let the students learn related knowledge eventually and sometimes was forced on the students, but this strategy was too slow for problem solving and thus should be avoided as much as possible; the index, BUG and entertainment strategies might be unique strategies for game based learning only, thus enough attention should be paid to them in the game design in the future and further research would be needed.

Another special problem with the problem solving process in the virtual learning environment that needed attention was "virtual problem compression." For example, the amounts of fruits and leaves shown in the game interface would change along

with the changes of the related figures, but the actual amounts could not be completely reflected; in addition, it was very easy to thin fruits in the game simply by clicking mouse, which made it possible to get only 4 fruits through too much fruit thinning—impossible in reality but possible in the game.

Obviously, problem solving is a very complicated process, and the process as well as the strategy may be affected by many factors that need further research in the future.

ACKNOWLEDGMENT

This research was sponsored by 2008 National Youth Foundation in Education of the National Social Science Foundation of China (Approval No: CCA080229) and the Research Grant Bureau Foundation of the University of Hong Kong (Serial No. CUHK4200/02H).

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KEY TERMS AND DEFINITIONS

Game-Based Learning: It is based on a concept that it is a type of learning in game environment or supported by games (especially digital games).

Problem Solving: People use comprehensive knowledge and skills to achieve the goal. In Farmtasia, the goal is managing the farm (including keep the plants and animals healthy, buy or sell productions) well to gain money.

VISLOE: It is a learning model that allows students to learn knowledge by themselves in a virtual game-based environment and through interacting with the others.