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Not just fun, but serious strategies: Using meta-cognitive strategies in game-based learning

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ABSTRACT

The purpose of this study is to explore the effects of the meta-cognitive strategies on the academic and gaming achievements. Exploring the effects of those achievements on the social problem solving of students is also of interest. For this purpose, the MMORPG *Gersang* was used. The participants, consisting of ninth graders, played the game until they all reached the third level to ensure that they have the same gaming ability prior to gaming for the study. Three meta-cognitive strategies were developed: self-recording, modeling and thinking aloud. Those strategies are specially related to gaming activities and applied in pre-gaming activities, gaming activities, and post-gaming activities. Three meta-cognitive strategies were set as independent variables. The social problem solving ability was set as a mediating variable, and academic achievement and scores in the game were chosen as dependent variables. The path between meta-cognitive strategies and both academic achievement and game performance by mediating social problem solving abilities were discovered. The social problem solving ability, which is the mediating variable, affects the academic achievement and the game performance very strongly. These results imply that a commercial game playing in conjunction with meta-cognitive strategies can be an effective way to increase students' performance both in learning and gaming by keeping them involved. Talking and observation activities such as thinking aloud and modeling are more effective than writing activities in enhancing the students' achievements both in learning and gaming.

1. Needs and purpose of this study

In recent years, there has been no shortage of efforts to design, develop, and apply educational computer games to game-based learning. Computer games have potential as a learning environment because they are a form of play that motivates students through entertainment. In addition, computer games have competitive activities that include rules, goals, feedback, interaction, and outcomes. As Bouras et al. (2004) suggested, gaming is becoming a new form of interactive content, worthy of exploration for learning purposes. In the same context, Dickey (2007) said that interactive learning environments allow learners to construct understandings by interacting with information, tools, and materials as well as by collaborating with other learners within the game. Games are seductive, deploying rich visual and spatial aesthetics that draw players into fantasy worlds that seem very real in their own terms, exciting awe and pleasure (Poole, 2000). To put it simply, games are engaging. They motivate students using entertainment, and this is a part of the natural learning process in human development (Bisson & Luckner, 1996).

According to this progress in game-based learning, several aspects of the learning process are supported. First, learners are encouraged to combine knowledge from different areas to choose a solution or to make a decision at a certain point. Second, learners can test how the outcome of the game may change based on their decisions and actions. Third, learners are encouraged to contact other team members to discuss and negotiate subsequent steps, thus improving, among other things, their social skills (Pivec & Dziabenko, 2004). The important central aspects of games include: searching for information; selecting appropriate and necessary information; developing discussion strategies; resolving conflicts; and exercising the decision making process and negotiation. In light of these steps, the target and the culmination

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of games is to reach a consensus in a problem solution (Bouras et al., 2004). However, as many educators already foresee, it is not an easy task to achieve the two objectives of education and entertainment with one solution (Baek & Kim, 2005; Korea Game Development, 2002; Mann, 1996). Often, the more entertaining a game is, the less effective it is as a learning tool; the converse is also true. In fact, the quintessential combination of entertainment and learning seems almost impossible to achieve. This ideal scenario comes from a natural mixture of both learning and game content. However, it is not easy to determine the intrinsic balance where both learning and gaming happen simultaneously. This has continued to be a contentious issue in the development of educational computer games.

Rather than designing and developing educational computer games requiring much time and effort, it is suggested that educational providers use commercially available games in game-based learning (Baek, 2006; Kim & Kim, 2005). This recommendation is supported by two factors; the first, is that it is time-consuming and expensive to design and develop educational games; the second is that educational games developed specifically for the purpose of education are not as engaging or attractive for students as commercial games. However, without relevant guidelines and instructional strategies, it would be very difficult to achieve the educational objectives of a game-based learning through the application of commercial games.

As game-based learning is focused on achieving the particular objectives of given educational content through game play, players' attempts to solve problems are maintained throughout the learning session. For computer game players to continue their learning and gaming, they should apply their own strategies to solve problems in a game. In game-based learning where they both study and play, learning strategies and gaming strategies are the same phenomenon seen from different perspectives, like two sides of one coin. Learning strategies and gaming strategies adopted to implement problem solving strategies in game-based learning may be the primary factor behind the high achievements in both learning and gaming. This implies that higher scores in learning and gaming require better problem solving abilities, which require, in turn, well-chosen strategies for both learning and gaming. The issue, however, is that educational computer games in formal education settings are not chosen by students but by teachers. Educational games for classroom use often differ in nature from games at home that are often more focused on entertainment than learning. Most commercial off-the-shelf games appeal to students' curiosity and pay more attention to entertainment than to education even though they are advertised as educational. Thus, teachers who want to bring commercial off-the-shelf games into their classrooms should be careful when selecting the games because they may not fit into the classroom in terms of time span, learning contents, and usage. But teachers cannot do as much about time span and learning contents for adopting games in the classroom as they can do on ways of usage: how to teach with games. In game-based learning, teachers should consider instructional strategies that focus on utilizing the game, especially when it is a commercial game. This is because students are asked to play a game and they need to find out how to solve a given problem to proceed in the game and obtain some knowledge from gaming.

Meta-cognitive strategies seem to play an important role in problem solving situations like gaming. Game players need to plan, check the initial plan, and choose other strategies if the original plan fails. Quite often, meta-cognitive strategies are applied to problem solving. In other words, students can enhance their problem solving abilities by using meta-cognition and applying meta-cognitive strategies. Lin (2001) said that practicing meta-cognitive strategies would help students improve their problem solving abilities. This implies that achievements in gaming and learning are affected by players' meta-cognitive strategies.

In this study, meta-cognitive strategies for gaming are developed and adopted to help students effectively exercise social problem solving skills. A Massively Multiple Online Role Playing Game (MMORPG), Gersang, was selected as a game-based learning environment to achieve this goal. According to Dickey (2007), a MMORPG provides a flexible learning environment which provides scaffolding for problem solving along with elements which foster intrinsic motivation. He suggested that a MMORPG is a persistent, networked, interactive, narrative environment in which players collaborate, strategize, plan, and interact with objects, resources, and other players within a multimodal environment. Gersang simulates the Korean economy of 200 years ago and it contains many aspects of economics, so one of the main objectives of this study is to reveal the effects of meta-cognitive strategies on students' achievement in economics. Students' social problem solving skills are also expected to be positively affected by the meta-cognitive strategies as they successfully proceed to play the game. This study tries to enlarge the scope of game-based learning by adopting commercial games already known to students and combining these games with well-developed learning strategies, rather than developing new educational computer games.

This study aims to discover the effects of meta-cognitive strategies on achievements of both learning and gaming via players' social problem solving in game-based learning utilizing commercial games which are known to be popular, engaging, and attractive to learners. Exploration of effects of social problem solving on both achievements in gaming and learning is also of interest. For this purpose, three meta-cognitive strategies of self-recording, modeling, and thinking aloud were developed and applied in the game-based learning. The specific research hypotheses are listed below:

1. There is a significant effect of the meta-cognitive strategies on both the achievement in gaming and the achievement in learning.
2. There is a significant effect of the meta-cognitive strategies on the social problem solving ability.
3. There is a significant effect of the meta-cognitive strategies via social problem solving on both the achievement in gaming and the achievement in learning.

2. Literature review

2.1. Meta-cognitive strategies in game play

Flavell (1976) defined meta-cognition as "knowledge concerning one's own cognitive processes and products or anything related to them" and stated that "Meta-cognition refers, among other things, to the active monitoring and consequent regulation and orchestration of these processes in relation to the cognitive objects or data on which they bear." Hype and Bizar (1989) defined meta-cognition as "a process where the individual carefully considers thought in problem solving situations through the strategies of self-planning, self-monitoring, self-regulating, self-questioning, self-reflecting, or self-reviewing" (p. 1). Also, McKeachie (2000) stated that meta-cognition is thinking about one's learning and thinking. On the other hand, meta-cognitive strategies are the instructional strategies that allow learners to use their meta-cognition in problem solving. According to Ridley, Schutz, Glanz, and Weinstein (1992), they include taking conscious

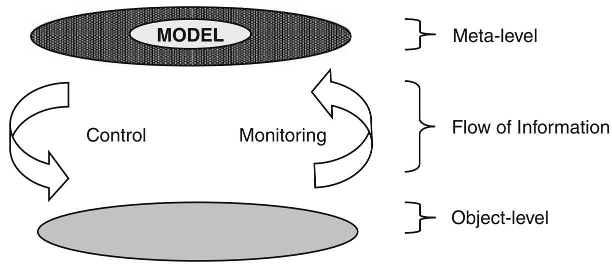

Fig. 1. A model of meta-cognition.

control of learning, planning and selecting strategies, monitoring the progress of learning, correcting errors, analyzing the effectiveness of learning strategies, and changing learning behaviors and strategies when necessary. Proceeding from what has been said above, in this study we define meta-cognition as the ability to understand and monitor one's own thoughts and the assumptions and implications of one's activities (Brown, Bransford, Ferrara, & Campione, 1983; Butterfield & Belmont, 1977; Falvell, 1979). Flavell (1979) proposed a formal model of meta-cognitive monitoring to include four classes of phenomena and their relationships. According to his model, "...a person's ability to control a wide variety of cognitive enterprises occurs through the actions and interactions among four classes of phenomena: (a) meta-cognitive knowledge, (b) meta-cognitive experiences, (c) tasks or goals, and (d) actions or strategies" (p. 906). Blakey and Spence (1990) proposed six strategies for developing meta-cognitive behaviors, these strategies include: identifying "what you know" and "what you don't know", talking about thinking, keeping a thinking journal, planning and self-regulation, debriefing the thinking process, and self-evaluation. Wahl (2000) presented three meta-cognitive strategies: planning, self-monitoring, and self-evaluation and these can lead to cognitive strategies as in concept maps and outlining. In addition, he presented some questions that facilitate the learners' meta-cognition, such as 'How much time do I need to set aside to learn this? (planning)', 'Do I understand what I am reading or learning? (self-monitoring)', and 'How can I measure my success? (self-evaluation)'.

Nelson and Narens (1994) presented a model of meta-cognition. The model explains the relationship between the meta-level cognition and object-level of cognition (Fig. 1).

The meta-level cognition monitors and controls the object-level cognition and the information between the two levels circulates. Luca and McMahon (2004) said that the meta-cognition was viewed as a pet puppy – people have to feed (monitor) the puppy and get her to exercise (control) so that the puppy could be strong. They stressed that educators can get students to have strong meta-cognition by feeding them information and getting them exercising in the same way.

Christine (2003) said that meta-cognitive strategies are necessary to aid students in comprehending a text and achieving higher levels of thinking. She focused especially on teachers' modeling and motivation to encourage students to make these strategies on their own. In sum, meta-cognitive strategies can be defined as strategies that empower learners to take charge of their own learning in a highly meaningful fashion. They are helpful for students who have learning problems. As well, they assist students in focusing their attention, understanding content, integrating new information with existing knowledge, and encoding and storing this information in a way that will facilitate memory and retrieval.

Zimmerman and Tsikalas (2005) stressed self-regulation including meta-cognitive processes. Phases and sub-processes of self-regulation have three cyclical phases and six sub-processes and include students' motivation and affective side in addition to meta-cognition. They explained these three phases as follows: first, the forethought phase includes not only task analysis processes which general meta-cognitive processes have but also self-motivation processes that empower learners to initiate their learning. Second, the performance phase includes self-control and self-observation processes that use the meta-cognitive and behavioral strategies. Third, the self-reflection phase includes self-judgment and self-reaction. This phase involves not only self-evaluation of meta-cognition but also affective reactions. They said that affective reactions could be causal attributions to personal control, feelings of self-satisfaction, and adaptive self-reaction. Zimmerman and Tsikalas's self-reflection model implies that studies on meta-cognition need to extend into learners' affective and motivational areas.

Games put learners in the role of decision-maker, pushing them through ever-harder challenges while engaging the player in experimenting with different ways of learning and thinking. Players experience the subject domain or situation in new ways, form new affiliations, and thereby prepare for future learning and problem solving in the domain or transfer of learning to related domains (Gee, 2003). Games may play the important role of an environment that utilizes meta-cognitive strategies. Using meta-cognition to select and use particular strategies in a given context for a specific purpose as in a game-based learning means that the learner can think and make conscious decisions about the learning process (Anderson, 2002). As students become more skilled at using meta-cognition, they may gain confidence and become more independent as learners in learning with games.

2.2. Social problem solving in game play

Games can provide a meaningful framework for offering problems to students (Kiili, 2005). In fact, a game can be a meaningful environment for problem-based learning. Problem solving in games is regarded as striving for a remote and not immediately attainable goal. Because the ability to solve problems is one of the most important of human skills (Holyoak, 1991), game-based learning which is a natural environment for problem solving is deemed to have the power to improve students' abilities in that area.

Social problem solving is defined as the self-directed cognitive behavioral process of trying to identify or discover effective or adaptive ways of coping with problems in daily life (D'Zurilla & Nezu, 1999). It is a conscious, purposeful, and social activity revolving around a problem. The word "social" implies the social context in which the problem solving takes place. A problem is seen as any life situation or as a present task requiring a response for a person's adaptation. The demands in a problematic situation could arise in the environment or within the person (Paul-Odouard, 2005). Thus, the study of social problem solving deals with all types of problems that might affect a person's functioning, including impersonal problems, personal or intrapersonal problems, interpersonal, as well as broader community and societal problems (Chang, D'Zurilla, & Sanna, 2004).

The problem orientation in social problem solving is an important issue. It can be distinguished into two general aspects (Chang, D'Zurilla, & Sanna, 2004): problem orientation and problem solving styles. Problem orientation operates to promote personal confidence, positive method, and a sense of emotional regulation in routine and stressful situation (Elliotte & Shewchuk, 2003). Within problem orientation, there are two specific dimensions: positive and negative. A positive problem orientation is a constructive problem solving cognitive set that involves the general disposition to (a) appraise a problem as a challenge (i.e., opportunity for benefit or gain); (b) believe that problems are solvable; (c) believe in one's personal ability to solve problems successfully; (d) believe that successful problem solving takes time and effort; and (e) commit oneself to solving problems with dispatch rather than avoiding them (Maydeu-Olivares & D'Zurilla, 1996; Morera et al., 2006). In contrast, a negative problem orientation is a dysfunctional or inhibitive cognitive emotional set that involves the general tendency to (a) view a problem as a significant threat to well-being; (b) doubt one's own personal ability to solve problems successfully; and (c) become easily frustrated and upset when confronted with problems (Maydeu-Olivares & D'Zurilla, 1996; Morera et al., 2006).

Each problem solver shows different styles in social problem solving such as rational, deliberate and systematic application of effective skills. These effective skills include: (a) problem definition and formulation; (b) generation of alternative solutions; (c) decision making; and (d) solution implementation and verification (Chang, D'Zurilla, & Sanna, 2004). In problem definition and formulation, the problem solver tries to clarify and understand the nature of the problem by gathering as much specific information and as many concrete facts about the problem as possible, identifying demands and obstacles, and setting realistic goals for problem solving. In generation of alternative solutions, the problem solver focuses on the problem solving goals and tries to identify as many potential solutions as possible, including both conventional and original solutions. The problem solver makes the alternative solution based on three principles: identifying a large quantity of solutions, deferring judgment of each solution until the decision making state, and identifying various strategies and approaches to the problem (Lesley, 2005). In decision making, the problem solver anticipates the consequences of the different solutions, judges and compares them, and then chooses the "best" or most effective solution based on the potentiality or utility. While the first three skills cover the process of finding a solution, the final step, solution implementation and verification, refers to the performance or carrying out of the solution. The problem solver carefully monitors and evaluates the outcome of the chosen solution after attempting to implement in the real-life problematic situation. This skill includes self-reward for satisfactory outcome or recycling back to the previous problem solving step for unsatisfactory outcomes (D'Zurilla & Goldfried, 1971; D'Zurilla & Nezu, 1999; D'Zurilla et al., 2002).

Social problem solving skills are very similar to skills needed in game play. Begg, Dewhurst, and Macleod (2005) proposed that the descriptive sequence of game play might be read as a model paradigm of problem-based learning. Problems in problem solving are equal to missions in game play. The three characteristics of problems in learning are: givens, goals, and obstacles (Davidson, Deuser, & Sternberg, 1994) which can be replaced with missions in a game, because game missions have these same characteristics.

Squire (2004) described the emergence of games as an entertainment medium and the increased recognition of games as complex problem solving spaces. In fact, problem solving is the essence of a player's actions in a computer game (Jørgensen, 2003). Jørgensen showed her philosophical approach to it by presenting the process of problem solving in a computer game as follows: the player's first task is to comprehend the nature of the problem. Second, the player develops a strategy linking comprehensive activity and physical action. In the third phase, the player's mental activity is realized as physical attempts to solve the problems, otherwise known as intentional action. In addition, most game's problems are social in nature. Barab, Thomas, Dodge, Carteaux, and Tuzun (2005) found the design of Quest Atlantis (QA) reflects the need for both action and reflection in evaluating its relevance to real-world problems, in constructing meanings in authentic settings, and in justifying the credibility of assertions. Schrader, Zheng, and Young (2006) argued that a degree of interactive collaboration should be a goal of classroom education. Grundy (1988) found that adventure games do have the potential to be an effective problem solving environment. Curtis and Lawson (2002) found that computer-based adventure games are productive environments for the development of general problem solving ability.

Dodge (1986) said that there are five stages in social problem solving such as encoding social cues, representation/interpretation of cues, response search, response decision, and enactment. He focused on determining and understanding social cues. Slaby and Guerra (1988) presented six steps for social problem solving: information seeking, defining the problem, selecting a goal, generating alternatives, generating consequences, and prioritizing responses. Dise and Lohr (1998) also presented six steps as follows: identifying relevant dimensions of a problem, generating alternatives, choosing a strategy, using feedback from the environment to determine efficacy, maintaining set while the strategy is working, and changing strategy when it is no longer working.

Begg et al. (2005) described game play as the following six processes. (1) When entering a gaming environment, a player adopts a character role or assumes an identity appropriate to the environment. (2) Once within the gaming environment, the player perceives tasks to be completed and, consequently, progress to be made. (3) In order to progress through the game's more complex levels, the player learns the necessary game vocabulary. (4) The player explores intriguing hidden corners and alluring vistas. (5) The player adapts to the gaming environment by interacting with it. (6) The player realigns expectations and judgments through each exploration and interaction, reappraising

Table 1
Procedure in game play and problem solving.

Procedures of problem solving[a]	Procedures of game play[b]
Problem definition and formulation	Adopting a role and an identity appropriate to the environment. Perceiving tasks to be completed and the progress to be made
Generation of alternatives	Learning the necessary game vocabulary and exploring intriguing hidden corners and alluring vistas
Decision making	Adapting and interacting
Solution implementation and verification	Realigning expectations and judgments through each exploration and interaction, reappraising the cause and consequence of each experience

[a] *Source:* Begg et al. (2005).
[b] *Source:* Chang, D'Zurilla, and Sanna (2004).

the cause and consequence of each experience accordingly. Procedures in game play can be matched to those in problem solving. Table 1 summarizes this comparison.

Identifying a task or mission in game play is similar to problem definition and formulation in problem solving. Obtaining items and exploring hidden threats/expectations are similar to generating alternatives in problem solving. The environment in the game changes according to each progress in game play, requiring player's decision making at each transition. At the end of each phase of the game play, realigning and reappraising happen and this helps the player to move forward in the game. These processes in game play also happen in problem solving. In particular, online games facilitate social interactions between players and provide an environment for enhancing player's social problem solving ability.

2.3. Developing meta-cognitive strategies for the study

2.3.1. Considerations in implementing meta-cognitive strategies

There are several considerations when implementing meta-cognitive strategies. First, meta-cognitive strategies should be implemented after the student has acquired an understanding of the concept/skill. Second, meta-cognitive strategies must be taught. Pressley and Associates (1990) mentioned that meta-cognitive strategies need to be taught since they are not an automatic response. Wood and Anderson (2001) wrote that meta-cognition does not occur automatically; "it is the result of long-term development of the cognitive system (p. 4)". Third, meta-cognitive strategies provide students the opportunity to practice independently, which, in turn, builds fluency and mastery of the skill. Fourth, student use and performance using strategies should be monitored. Lin (2001) asserted that teachers need to model meta-cognitive strategies since "students need to be taught these strategies, they are not born with them (p. 23)". After the teacher models the strategies, the students need time to practice them in an environment that promotes their learning. Games can be a good environment that provides students with the opportunity to practice meta-cognitive strategies.

2.3.2. Three meta-cognitive strategies in game play

This study supports the definition of meta-cognitive strategies as "the specific activities activating meta-cognition." However, it is not easy to control learners' meta-cognition because it has no physical form. Therefore, physical activities such as watching, listening, speaking, writing, and operating are needed to control and activate meta-cognition. In this aspect, game play is a fascinating activity for activating meta-cognition, because it is a series of activities of watching, listening, speaking (writing), and operating. In this study, three meta-cognitive strategies were developed for game play based on three dimensions of meta-cognition: self-planning, self-monitoring, and self-evaluation (Blakey & Spence, 1990; Hacker, 2006). These are depicted in Fig. 2.

The meta-cognitive strategies developed in this study are self-recording, modeling, and thinking aloud. The self-recording is a writing activity, the modeling is a watching activity, and thinking aloud is a listening and speaking activity to facilitate students' meta-cognition.

2.3.2.1. Self-recording. Self-recording is a strategy to record experiences related to the learning plan, learning process and learning outcomes. In other words, students record their plans and are engaged in a process of reflective thinking by looking back on their gaming activities to improve their meta-cognition. Self-recording has three phases in this game-based learning process. The first phase is recording their prior knowledge before they start game play. The teacher presents the 20 learning concepts about economics that should be learned through playing Gersang. Students choose one learning concept and write on their recording sheets what they already know and what they do not know yet. The second phase is recording their activities every 10 min. On the teacher's signal, players have to record their activities of the past 10 min and determine if their activities were related to the game mission or not. They can have time for self-monitoring and avoid time-consuming activities for achieving game mission. The third phase is recording reflections. In this phase, upon finishing their game play, students write a short reflective journal about their game play.

2.3.2.2. Modeling. Modeling is a self monitoring activity which takes place through observing others and is of great help to players in making strategies their own. There are five modeling strategies that players follow: first, they identify the game missions and the activities required to achieve those missions. Second, students determine the target player to observe during game play. Third, they observe the target player's game play and conceptualize their own strategies. This helps player's gaming by observing and adopting effective strategies from the target player. Fourth, students play the game-based on their own strategies during the game play. Fifth, students evaluate their

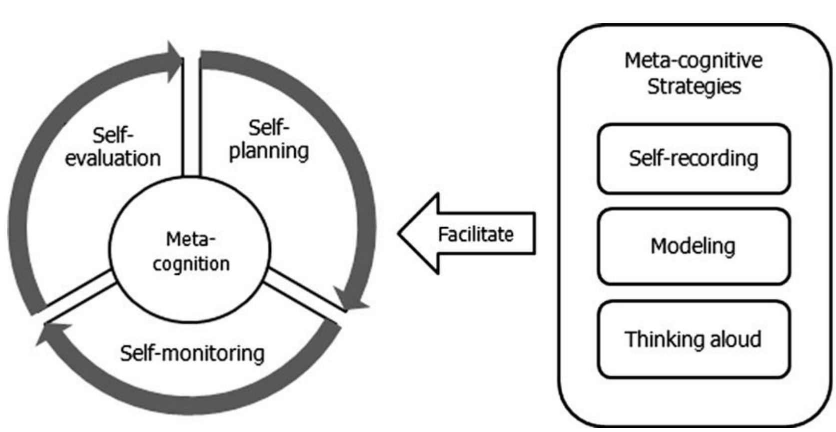

Fig. 2. Meta-cognitive strategies that facilitate meta-cognition.

efficiency of game play according to level, power, and items compared to the target player. In this study, students had a 10 min break during every gaming session to observe other players' gaming. They then analyzed and recorded others' game activities and obtained the information they needed. Students were also asked to talk about their activities and behavioral solutions regularly for them to verify their plans and degree of modeling the activity process.

2.3.2.3. Thinking aloud. "Thinking aloud" is a verbal expression of the normally covert mental processes. Caldwell, Jennings, Lerner, and Richek (1996) found that students learn comprehension strategies when "teachers model the thinking process out loud to his or her students." They said that this modeling could be on predictions, mental images, correcting misunderstandings, or main ideas and details. Students should talk to their fellow students about their game play during every game session. Students apply the thinking aloud strategy in the game through the following steps: first, the teacher makes a cooperative gaming group and explains how to use the thinking aloud strategy. Second, students relate their game plan to the learning objectives using several glossaries before they commence game play. For example, "I will learn about 'inflation' through game play today. 'Inflation' is a general increase in the level of prices accompanied by a fall in the purchasing power of money." Third, students explain their game process to their fellow players throughout the game play. They explain what is on mission, what is off mission, and what they will do in the next game session using several glossaries. For example, "I should have money for getting a good house," "It is a good job that I did sell the item," and "I will deal with the Japanese merchant until the game is over."

3. Research method

3.1. Participants

The subjects used for this experiment were drawn from a middle school located in Incheon, South Korea. The participants were composed of 132 ninth grade students who had never played the game *Gersang*. Their age ranges from 15 to 16. Informed consent to participate in this study was obtained from the parents of the students before the implementation of the experiment.

3.2. Instruments

3.2.1. The on-line game

There are many genres of computer games including action games, adventure games, strategy games, role playing games, and so on. In this study we used a commercially available MMORPG known as *Gersang*. The word *Gersang* means 'wealthy merchant' in Korean. *Gersang* is a popular MMORPG in Korea that is set in the economic context of the Choseon Dynasty about 200 years ago. *Gersang* has two separate subscenarios: an economic scenario and a battle scenario. Players receive a variety of quests from Non-Player Characters (NPCs) and have to solve these quests to become a wealthy merchant. In the economic scenario, *Gersang* allows the players to experience economic activities such as inflation, deflation, currency exchange, investment, international trade, and factory management for goods production. In the battle scenario, *Gersang* allows players to battle for better weapon items and an upgraded player level. *Gersang* has been used as a main activity in Strategic Management courses in the College of Business Administration at Chung-Ang University, South Korea.

The learning goal of *Gersang* is to understand and apply the principles of a market economy. For the purpose of this study, *Gersang* was reviewed by three separate experts: an economics expert, a gaming expert, and an educational technology expert. These experts extracted twenty economic concepts relevant to the "Understanding a Market Economy" lesson from ninth grade social studies in middle school. These concepts include, scarcity of resources, opportunity cost, productivity, economic freedom, currency exchange, supply and demand, international free trade, and so on.

3.2.2. Social problem solving ability inventory

The social problem solving inventory-revised (SPSI-R) by D'Zurilla et al. (2002) was selected and adapted by the authors. SPSI-R consists of 52 items and five subscales such as positive problem solving (PPS), negative problem solving (NPS), rational problem solving (RPS), impulsivity/carelessness style (ICS), and avoidance style (AS). The authors revised the SPSI-R by selecting 28 items from the original 52 and translating these to Korean. Those items in the questionnaire that ended in negative predicates were changed to end in positive predicates. The Cronbach's α value of the inventory was .921.

3.2.3. Achievement test

An achievement test prepared by the Incheon Metropolitan Office of Education was administered to participants. The achievement test was used to measure students' achievement in learning. This test was used to assess the students' knowledge of economic principles covered in the game *Gersang*. This achievement test was composed of 20 multiple-choice questions and each question was weighted equally. The Cronbach's α value of this test instrument was .941. The items of this test are related to educational objectives and learning content of ninth grade social studies as shown in Table 2.

Table 2
Achievement test.

Educational objective	Learning content	Items
Economic knowledge	Economic facts	1, 5, 6
	Concepts	7
	Generalization	3, 8, 9, 10, 11
	Theory	2, 4, 17
Economic function	Scientific thinking process	12, 13, 16
	Decision making process	14, 15, 18, 19, 20

For example, item no. 8 tests 'generalization' and is related to 'economic knowledge'. Item no. 8 is as follows:
[Item 8] Which of the following does not correctly explain pricing in a market economy?

① The government decides.

② The supply decides.

③ The demand decides.

④ It influences production.

⑤ It acts like traffic signals.

3.2.4. Game scores

Participants' gaming ability was measured by the game's level scores. *Gersang*'s scoring system includes credit scores and battle scores. The two scores have a positive correlation; the more players gain credit scores, the more players win battles. The achievement score in gaming was the sum of the two scores. The two scores produced a scoring range from 0 to 100.

3.3. Procedure

The experiments began with pre-tests on academic achievement and social problem solving ability being administered to the participants. After the pre-tests, the teacher explained how to play the game and the how to use meta-cognitive strategies. The participants then played *Gersang* until they all reached the third level. This was done to ensure that players have the same gaming ability. Also, the meta-cognitive strategies were explained to the participants in detail. They played the online game, *Gersang*, 45 min a day, twice a week, for 10 weeks. They were given three checklists for the meta-cognitive strategies. Game-based learning session can be described as below:

Before each session, the teacher presents the 20 economic concepts that should be learned. Players choose one concept and record it on their sheet. They then make a list of what they already know about this concept and what they do not know yet. Next, they have to identify the game missions and the activities required to achieve those missions. Players are now ready to select the target player to be observed. During play, the participants play *Gersang* and apply the three meta-cognitive strategies of their own. After play, players complete the three checklists, measuring how often or how much they used the meta-cognitive strategies during game play. They evaluate themselves and complete these checklists every 20 game-based learning sessions. The post-test for social problem solving ability was administered on the last session. The post-test for academic achievement was also completed by players on the last session. Game scores obtained in *Gersang* were used as a score for their gaming achievement.

The social problem solving ability post-test was administered on the last day of class. Likewise, the academic achievement post-test was also completed by the students on the last day of class. Game scores were drawn after the class as a score for their gaming achievement.

3.4. Data analysis

The primary dependent variable is the achievement in learning economic principles. The secondary dependent variable is the achievement in gaming. Quantitative data were collected and analyzed using SPSS 15.0 for Windows and AMOS 7.0. The independent variables in this study are three meta-cognitive strategies: self-recording, modeling, and thinking aloud. The mediating variable is social problem solving ability. In this study, the structural equation model, not multiple regressions, was applied for data analysis. Because multiple regression analysis does not explain relative effects of independent variables, it cannot explain each variable's variance among total variance. As an alternative, path analysis was used. Path analysis was conducted to examine the correlations and causal relations between the independent and dependent variables. Developed by Sewell Wright in the 1930s, path analysis is usually used to understand the relationships among variables. In path analysis, covariance or correlation coefficient is used to do causal analysis. It can be used to understand direct and indirect effects as well as quasi-effects that are hard to observe in multiple regression analysis. This means of analysis is used to find the regression coefficient of the linear structure formula among the variables set by the investigator.

Table 3
Correlations between variables.

	Self-recording	Modeling	Thinking aloud	Achievement in learning	Achievement in gaming	Social problem solving ability
Self-recording	1					
modeling	.171*	1				
Thinking aloud	.171*	.136	1			
Achievement in learning	.460***	.393***	.324***	1		
Achievement in gaming	.225**	.676***	.138	.491***	1	
Social problem solving ability	.173*	.064	.481***	.469***	.293**	1

* Correlation is significant at the 0.05 level.
** Correlation is significant at the 0.01 level.
*** Correlation is significant at the 0.001 level.

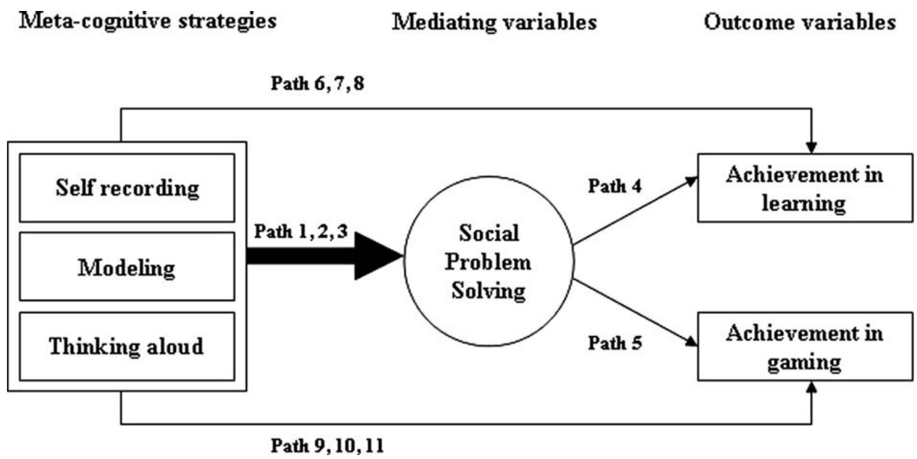

Fig. 3. Path model among variables.

The descriptive statistics are presented in Table 4 with Estimates, SE and CR. Fitness indices are provided because they have their own meaning.

4. Results

4.1. Analysis of correlations between variables

A correlation analysis was performed to determine the relationship among all the variables. Table 3 shows the correlation coefficient among variables.

Of the meta-cognitive strategies, thinking aloud and self-recording appear to be significantly related to the social problem solving ability. Self-recording and modeling are significantly related to the achievements both in gaming and learning. The social problem solving ability has a statistically significant relation to the achievements both in gaming and learning.

4.2. Path analysis between the variables

The research model was established based on the idea that the meta-cognitive strategies have an effect on the social problem solving ability and that the social problem solving ability have an effect on the achievements of both in gaming and learning. The path model is presented in Fig. 3.

In assessing the model, the authors relied on several standard fit indices to examine the overall model fit: the change in the chi-square relative to the change in degrees of freedom, the ratio of chi-square to degrees of freedom (χ^2/df), goodness of fit (GFI), and adjusted goodness of fit (AGFI). Fit indices for the measurement models are presented in Table 4. These indices indicate a satisfactory fit for the model. Goodness of fit of structural equation model used in this study was to prove fidelity between data model and research model.

To evaluate the appropriate the fitness of the measurement research model, the fitness indices such as $\chi^2(p)$, Q(χ^2/df), goodness-of-fitness index (GFI), adjusted goodness-fitness index (AGFI), CFI, and RMSEA were calculated as in Table 4. The chi-square (χ^2) was 14.169, *p* (probability level) = .007, $Q(\chi^2/df)$ = .3.542. The chi-square/degrees of freedom ratio was 3.542, the GFI = .964, the CFI was .953, and the RMSEA was .000, indicating that our structural model was a satisfactory fit for the data. The normed fit index shows 93.9% of goodness of fit and the relative fit index .770 is close to 1. Because these statistics satisfy the criteria to prove the model fidelity, it is concluded that this model is acceptable for analysis about the model goodness of fit.

4.3. Path analysis model

In order to verify the research model, path analysis was performed using AMOS version 7.0. The technique was performed using analysis of moment structures maximum likelihood estimation. Results of the path analysis of the relationship between the variables are displayed in Table 5. In this table, 'Estimate' means 'regression parameter', 'S.E.' means 'Standard Error' and 'C.R.' means 'Critical Ratio'. Significance can be evaluated by the values of 1.96, because the 'C.R.' is '*t*' value of regression analysis.

Generally, if the C.R. value is higher than 1.96 in α = .05, the effectiveness is regarded as significant. The authors tested all null hypotheses at the α = .05 level with data. The findings show that the thinking aloud strategy has a significant effect on social problem solving abilities in this game-based learning (.411, $p < .05$). Furthermore, social problem solving ability has a significant effect on both the achievement in learning and the achievement in gaming (.372 and .414, $p < .05$).

Table 4
Summary of fit indices for measurement models.

Fitness index	χ^2	Q	GFI	CFI	AGFI	RMSA	TLI	IFI	RFI	NFI
Research model	14.169	3.542	.964	.953	.809	.000	.824	.955	.770	.939

Table 5
Estimate of path coefficient.

Paths	Estimate	S.E.	C.R.	*p*
Social problem solving ability ← self-recording	.061	.048	1.262	.207
Social problem solving ability ← modeling	−.011	.051	−.213	.832
Social problem solving ability ← thinking aloud	.411	.067	6.129	.000
Achievement in gaming ← social problem solving ability	.414	.083	5.015	.000
Achievement in learning ← social problem solving ability	.372	.089	4.187	.000
Achievement in gaming ← self-recording	.237	.046	5.210	.000
Achievement in gaming ← modeling	−.118	.077	−1.527	.127
Achievement in gaming ← thinking aloud	.047	.072	.658	.510
Achievement in learning ← self-recording	.065	.049	1.334	.182
Achievement in learning ← modeling	.229	.048	4.763	.000
Achievement in learning ← thinking aloud	.572	.052	11.027	.000

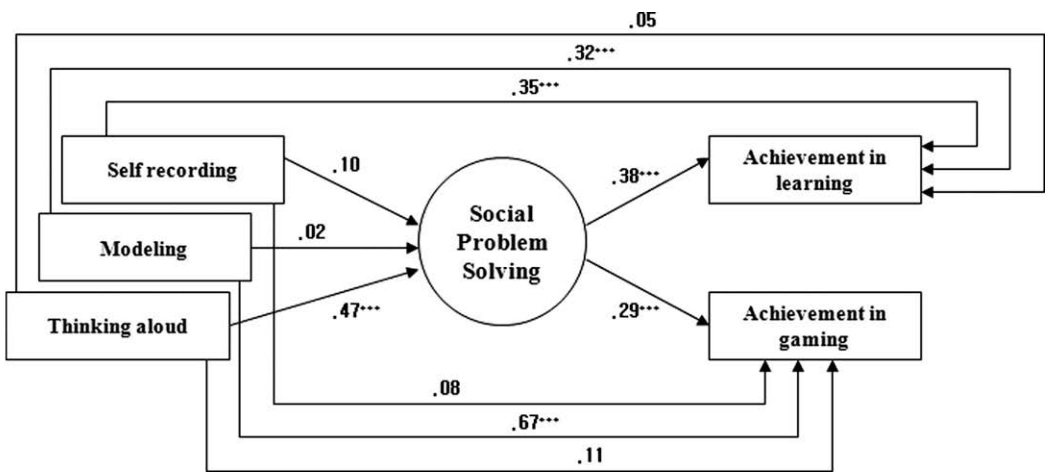

Fig. 4. The path analysis model.

Results of the path analysis are shown in Fig. 4. Hypothesis 1, which stated that the meta-cognitive strategies have a significant effect on both the achievement in gaming and the achievement in learning, was supported by the effects of self-recording ($\beta = .35$, $p < .001$) and modeling ($\beta = .32$, $p < .001$) on the achievement in learning and the effects of modeling on the achievement in gaming ($\beta = .67$, $p < .001$). Hypothesis 2 was that the meta-cognitive strategies have a significant effect on social problem solving. As expected, thinking aloud was one of the meta-cognitive strategies that had a positive and significant effect on the social problem solving ($\beta = .47$, $p < .001$). But the remaining strategies of self recording and modeling did not have a significant effect on social problem solving. The proposed hypothesis 3 stated that the meta-cognitive strategies have a significant effect on both the achievement in gaming and the achievement in learning via social problem solving. As predicted, social problem solving had positive effects on both the achievements in gaming and in learning (Fig. 4).

5. Conclusions and implications

Through this study, the researchers sought to investigate the effects of meta-cognitive strategies on problem solving ability and achievements in game-base learning. This study revealed that among three meta-cognitive strategies developed for effective game-based learning, the 'thinking aloud' strategy is the strongest variable affecting social problem solving ability. In other words, discussing game play with peers during break sessions positively affects their social problem solving ability. The second strongest variable is 'modeling'. Modeling is also an activity that students do with peers. The weakest variable is 'self-recording', where students record their game activities during break sessions. These results were as expected because self-recording is an individual activity rather than a social one. Social problem solving, which is the mediating variable, affected both achievements in learning and gaming very strongly. One of the possible reasons why social problem solving has such significant effects on both achievements is that the game-based learning deployed a MMORPG in which players have to use social interaction and social skills a part of the game mission.

Conclusions which can be drawn from this study are as follows. First, a commercial off-the-shelf game in game-based learning in conjunction with meta-cognitive strategies can be an effective learning environment for increasing students' performance. Therefore, it is desirable for teachers to find the educational aspects of commercial off-the-shelf games, map them onto their curriculum objectives, and apply meta-cognitive strategies for players in order to secure learning effectiveness. This study suggests that teachers and parents need to change their primary views regarding game-based learning. They need to focus less on the elements of violence and addiction which have been major obstacles for using games in the classroom and focus more on the educational potential of commercial games by adopting teaching strategies such as meta-cognitive strategies. If this is done, then commercial off-the-shelf games might be accepted as an effective teaching and learning tool in formal educational settings. Second, talking and watching strategies such as thinking aloud and modeling are more effective than writing activities in enhancing the students' performance in game-based learning as long as the game is social. This finding urges teachers to devise certain strategies such as meta-cognitive strategies to help students' activities in game-based learning. Talking and modeling are socially interactive and have more significance, while writing is very individual and less effective in promoting achievement. This may be because this study is designed to enhance social problem solving ability with a view to increasing achievement. For this reason, teachers have to identify the types of proposed learning outcomes in game-based learning and choose proper gaming activities suitable to them before bringing any commercial games into their classroom. The critical point for this would be to develop strategies in order to help player's active and effective cognitive activities according to the game genre as well as the learning content. In this sense, other strategies such as self-regulation are to be developed and deployed for increased performance in gaming and learning. The possible interpretation of this result is the mediation by Vygotsky. According to the Vygoskian view, mediation is the mechanism through which external and social activities are transformed into internal and mental cognition (Vygotsky, 1978). Karpov and Haywood (1998) said that Vygotsky's writings suggest meta-cognitive mediation and cognitive mediation as the mechanism of children's learning and development. Among them, meta-cognitive mediation refers to the acquisition of semiotic tools of self-regulation. Karpov and Haywood discussed about "guided discovery in a community of learners (GDCL)" based on the Vygotsky's idea that the basis for development of children's self-regulation is their experience in regulating the behavior of others. Matching these views, the three meta-cognitive strategies could mediate between their game-playing and cognition. Thinking aloud and modeling could transform into self-regulation in learning. Another possible interpretation of this result is the interaction in peer-assisted learning. Thinking aloud and modeling strategies are assumed to play a role in peer-mediation. These two strategies allow students to interact with one another more than a self-recording strategy could. Fuchs et al. (2001) found that Kindergarten-Peer Assisted Learning Strategies make students outperform on students' phonological awareness and reading skills. Shamir and Lazerovitz (2007) found that peer mediation groups scored significantly higher than did the control group in both the process and outcome of self-regulated learning. They attributed this result to the meta-cognitive level. In other words, they assumed that the child's greater self-regulated learning capacities came from the heightened levels of meta-cognitive knowledge, meta-cognitive experience, and meta-cognitive control acquired throughout the peer mediation intervention.

Most educators have been worried that game play has a negative effect on academic achievement while students spend a great deal of time playing commercial games. However, even commercial game play can be helpful to the academic achievements of players in addition to enhancing their social problem solving ability. This may justify educators' participation in designing, developing, and utilizing educational games as well as commercial games not just for fun, but with serious strategies.

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