Developing a digital game-based learning system on insight problem solving

Yu Hsin Hung[#1], Chun Fu Lin[*2]
[#1] Department of Computer Science and Information Engineering, National Taiwan University, No. 1, Sec. 4, Roosevelt Rd., Taipei 10617, Taiwan (R.O.C.)
[# 2]Department of Engineering Science and Ocean Engineering, National Taiwan University, No. 1, Sec. 4, Roosevelt Rd., Taipei 10617, Taiwan (R.O.C.)

***Abstract*—** *Multi-media technologies have flourished, different kinds of materials used in the design of learning activities have attracted a considerable amount of attention from researchers. Insight problem-solving abilities perceived as critical ability and recently have become a popular training item in learning systems. However, the content of learning is designed with various types of learning materials, and the suitable materials employed in the learning activity could enhance training performance. Accordingly, we develop a game-based insight problem-solving learning system (GIPS) based on animated technique and the insight problem-solving theory. The GIPS includes a series of tasks for training the learner in exploring the solution when they face the diverse challenges. The aim of this study was training the leaner in problem solving ability, and enhancing the self-regulation of leaner which is concerned with the potential cognition load in the learning effectiveness and motivational appeal.*

***Keywords*—** *insight problem solving, game-based learning, animation technique. self-regulation*

I. INTRODUCTION

Some scholars indicated that the insight problem solution exploring is relevant to reconstruct the problem. Kohler (1925) pointed that the process from repetitively thinking problem content to realize a new solution may make learner in a relatively unexpected manner [1]. The process of insight with respect to problem solving skills is raised more interesting than ever, and research of the training material has been paid much attention [2]. However, the cognitive mechanisms of insight remain largely unknown, thus many studies develop the relative system as the platform to explore learner's cognition toward problem solving. At the same time, the development of problem solving learning system becomes a popular trend on educational psychology research. In recent decades, multimedia was widely used to web based learning [3] [4]. Multimedia employed in the learning system enriches the content of learning; the diversity of presentation is benefit for enhance learning motivation.

The content of learning has different presentation of multimedia [5], and multimedia based material plays essential role on learning system. For example, the dynamic material (e.g., animation, audio) conveys changes in the described movement and phenomenon over time. However, the explosions of multimedia-based material design have the uniqueness of technology acceptances on learning system. The game-based mechanisms have the most potential to improve the learners' learning performance than the other multimedia materials. Game-based materials are widely used to e-learning system to make the learner in the enjoyable manner while they are using the system [6]. Moreover, information and communication technology (ICT) empowers learners interact with multi-media material on web based learning platform. Based on the web technology, the material and learning content could be timely retrieved [7], thus various kind of learning material recently is extend applied in learning activities. Therefore, the insight problem solving theory, animation technique and game-based learning mechanism were employed to conduct GIPS which is based on the framework of web technology. In this study, we set the goal and kernel visions of GIPS (see Fig.1). GIPS conduct based on the kernel vision, we design series of heuristic challenges and diverse scenarios in the game task, in order to provide the joyful game for learner.

Fig. 1. The kernel vision of GIPS.

II. RELATED WORK

A. Game-based learning

Comparing the learning performance difference between the different materials has engaged the attention of many researchers [8]-[10]. The different learning materials affect learning performance in unique ways. Dynamic materials such as animation [11], audio [12], and game-based material [11] [12] have a more positive effect on attracting the learner's attention and arousing their interest than static textual material. On the view of problem-solving activities, the learning performance might determine that the effects of different multimedia materials. Game-based learning, in particular, is defined as one of the learning materials that aim to improve learners' problem-solving abilities. The challenge and task is based on educational theoretical basis, leaner can solving the problem to achieve the goal in the game scenario [13]. Applying game techniques in learning activities aims to enhance learning motivation and eliminate the cognition load. Some scholars show that games can be a stimulating motivator for learner [12] [14]. In digital learning, game-based learning systems have been considered as an innovative development, the characters of game have important contribution on learners' mental reflection. Accordingly, game techniques are included frequently as a positive component of individual learning.

Various types of materials applied in problem-solving activities engaged researchers' attention. Research has indicated that visual material could not only promote problem-solving transfer, but also strength problem-solving comprehension [15] [16]. Höffler et al. (2003) pointed that the developed visual style may be congruent to a certain degree [16]. To support this view, some researches indicated that animation provides explicit external representations. Therefore, the cognitive style is the main difference between animation and static material [16]. Animations are employed to provide learners with compensatory illustration with less pronounced visual styles, [17] and it also enable a mental representation with a less developed visual style [18]. To summarize, animation is effective for helping learners to imagine processes and conduct a mental representation. Accordingly, it is considered a good tool for problem-solving activities. This study employed animated material in problem-solving activity to impress the learner with its dynamic display of text and picture.

B. Insight problem solving

Problem solving can be defined as the complete evolution of exploring the solution (see Fig.2). Before planning the solution, the problem should be understood. Sternberg develops the problem solving model [19]. The procedure of problem solving model as follows:

- Step 1- Identify the nature of the problem.
- Step 2- Problem analysis to develop the problem-solving procedures and strategies.
- Step 3- Generating possible strategy by choosing and allocate the optimal information and resources.
- Step 4- Implement the solutions.
- Step 5- In the end, the problem-solving process should be monitored.
- Step 6-.Selecting the best solutions.

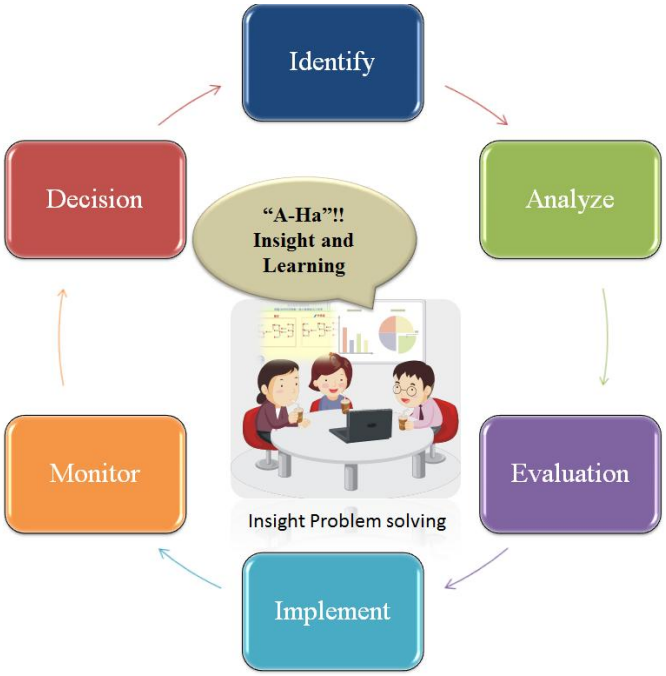

Fig. 2. The evolution of problem solving

Problem solving activities aim to employ the concept of the problem-solving model in learning activities to train the learner in the ability to deal with problems, and get insight from the procedure of solution finding. In addition, problem-solving collaborate with web-based system has attracted a considerable amount of attention from researchers [10], the main reason the dynamically retrieval. In this study, we develop GIPS based on the framework of web technique.

C. Self-regulated mechanism in game-based learning

Many studies indicated that the self-regulated ability is correlated with leaning intention. Chou et al. demonstrated that learners can engage in more in-depth and broader learning experiences, while they obtain self-regular learning [24]. Some studies support this view and indicated that the learner with capable of self-regulated have higher opportunity of obtain greater learning achievements, because they can use different learning strategies efficiently and have higher motivation in learning activities, which have positive effect on learning achievement [21] [22]. Rogers (1983) showed that learners have intention to practice self –regulated learning when they realize that learning can improve them and have the innate desire

to learn [27][28] The related study pointed that self-regulated learning is a proactive process used by students to acquire academic skills [23]. This process is consisted of series of steps: selecting and deploying strategies, and self-monitoring [25]. Bruner pointed that the interest is the best learning motivation in the teaching material. The adequate material to fulfill the student's needs is helpful to stimulate strong cognitive drive [29]. Accordingly, to increase the learning performance, providing the guidance for learner is needed. Therefore, leaners can develop self-regulated behaviors by themselves. In recently decades, self-regular learning widely applied in the game-based learning [22] [26]. The main reason is cognition is important in the games development to identify adequate strategies capable of problem solving encountered [26]. In this study, the self-regulated theory is employed in GIPS to develop the insight problem solving.

III. Methodology

In this study, the GIPS was developed to conduct game-based learning using web techniques, which consisted of an animation-based game technique, insight problem-solving material such as puzzle game. The GIPS include the problem solving theory and leaning emotion theory as theoretical basis, the problem solving model employed to design the game scenario, and the procedure of playing GIPS is based on self-regulated learning theory.

A. The learning activity design

Zimmerman (2002) proposed the three-phased cyclical model; these phases sequentially influence each other, while exerting an impact on the subsequent learning state. In this study, three-phase self –regulated learning [22] [30] were applied in in the learning activity (see Fig.3). The learning activity aims to strength the leaners' self- regulation toward the problem solving. On the purpose of achieving learning goal and accomplish the game task, learners adopt a range of insight problem solving game to construct new knowledge through actively implementing the resource management, and solution strategy development in the learning process.

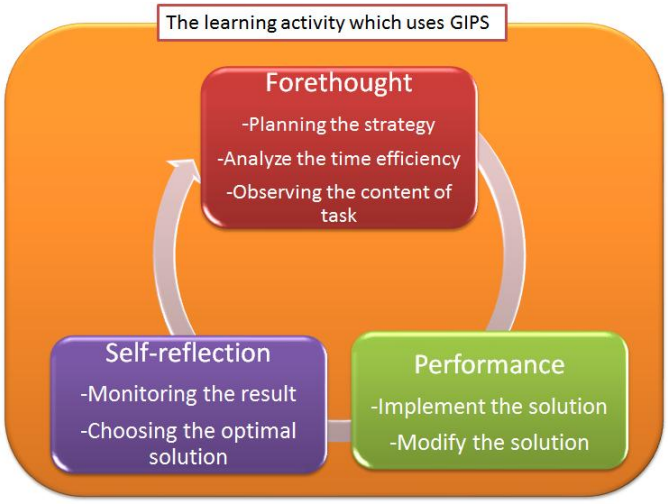

Fig. 3 The cyclical model of self-regulated learning applies in the learning activity which uses GIPS

B. The learning tool -GIPS

Fig.4 shows the structure of the GIPS, which consisted of an animation-based problem-solving game, problem solving theory and knowledge management (KM). KM is essential for information administration in the GIPS. The material database was established to collect information from users share their idea about learning materials. Learning database collected the results of the game for learning strategy decision support. The problem solving model applies in series of game design as theoretical basis.

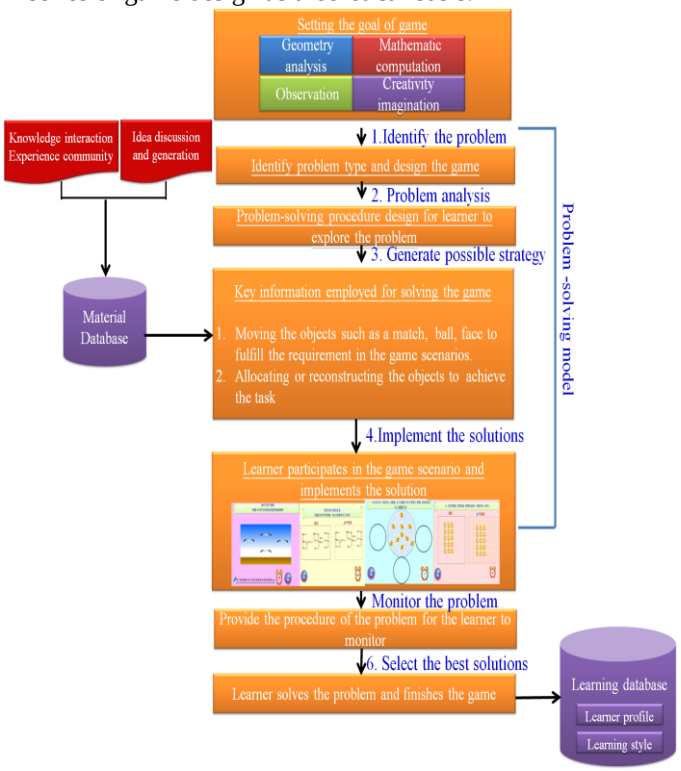

Fig. 4 The architecture of GIPS and problem solving model

First, the learning goal and the problems need to be defined in the game scenario.The aim of the game is to motivate learners' to improve their capable of problem solving in geometry analysis, logical analyzing, mathematic computation, and creativity imagination. In this study, the goal is aimed at these four dimensions. Then we identified the problem type and designed the problem. The aim of game-based problem development is that the learner can identify when they have observed a problem. The procedure of a problem-solving game has been well defined to let the learner understand the scenarios and discover the potential solution. Second, for editing the procedure of the game, represent and organize the information about the problem is needed. Therefore, the problem solving procedure is developed based on the key information included in the brainstorming lists and fact files. Key information was created for the learner to find in order to solve the problem in the game, such as the order of objected, which helps the learner realize the potential solution. The essential information provided in the form of helpful clues could help the learner to make a strategy. Training learners in to make a strategy has a positive effect on their problem-solving abilities. Third, each game has different constraints for learner to practice the resources allocation to generate the solution for solving the problem. Fourth, the procedure of problems that have were recorded in the game and shown to the learner to monitor the problem. Each movement have label with color, the learner is in the process of solving the problem while occasionally checking the progress in terms of resources and reaching a solution. Finally, the learners obtain the solution by exploring the problem and making the necessary adjustments. The result of the game is collected in the learning database.

IV. Result

The elements of a game play a critical role in the GIPS, the problem-solving model employed to the game scenario design. In the beginning, learners in the gaming progress were asked to solve the problem by executing the correct answer. Each of games has the time counter, which records the time constraint of game; the learners can monitor the time counter to evaluate the time validation. Animation-based problem-solving games consist of four main training factors: geometry analysis, logic analysis, and mathematic computation, creativity imagination. We developed 40 mini animation games; each one was developed based on these four essential factors. Some of learning material is referenced from [31]-[32].

A. Game instruction

GIPS instructed the learners in the game operation with textual description and a video demonstration (Fig. 5).

Fig. 5 The interface of game instructions in GIPS

B. Forty digital insight problem- solving game

The person fails to solve the problem and then suddenly realize the solution, that is the "aha!" means which is the process of insight in problem solving occurs. Two contemporary theories have been proposed to explain insight. Knoblich et al. (1999) developed the representational change theory [30] in which proposed that insight occurs through decomposing chunked problems and relaxing self-imposed on constraints of problem. Knoblich et al. (2001) designed matchstick arithmetic problem diagram to investigate the difference between successful and unsuccessful participants in the intervals of the problem solving period. Along with this point, some researcher start to design some puzzle game to exploring the emotional state in insight problem solving. In GIPS, we developed 40 insight problem-solving games based on the web technology and animation technique. Fig 6-Fig. 8 demonstrates the game which classified into three parts: matchstick arithmetic problem, arrange problem, and reconstruction problem, respectively.

Fig. 6 The insight problem-solving game - matchstick arithmetic problem

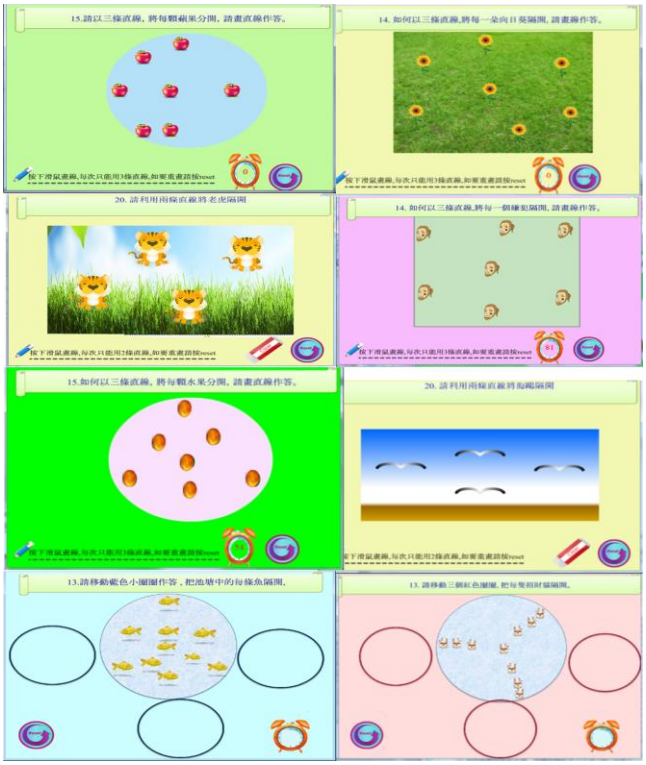

Fig. 7 The insight problem-solving game - arrange problem

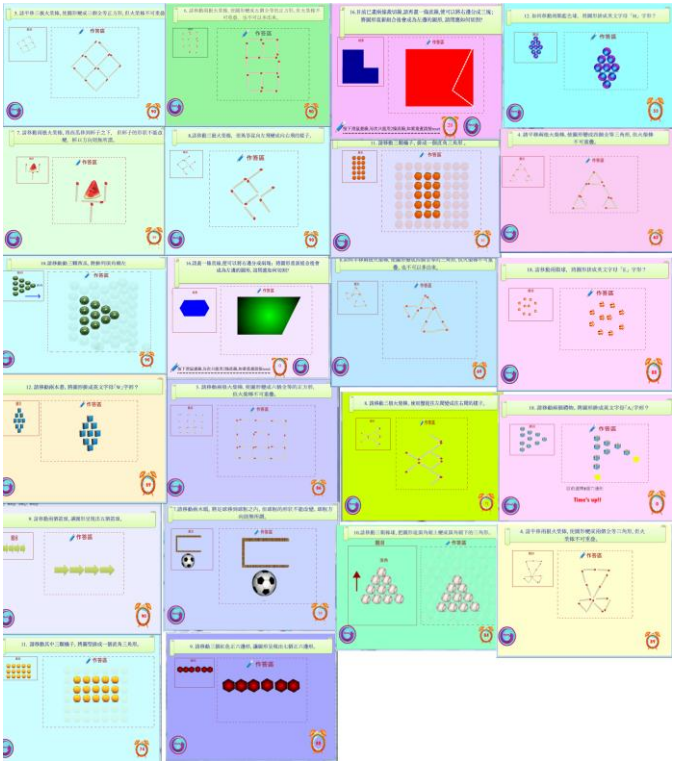

Fig. 8 The insight problem-solving game - reconstruction problem

V. Conclusions

In this study, we successfully develop GIPS which includes the problem solving theory and self-regulated learning. This study is lacked of sample size to validate the performance of GIPS. Future studies should increase the sample size and investigate learning attitude, emotional state, cognition factors that contribute to personalize learning. We will develop an optimization learning algorithm to provide a personalized insight problem solving learning activity that fits the individual's needs. In addition, the GIPS is expected to be developed as a mobile application and widely used on mobile devices, which will address the need for ubiquitous learning.

References

[1] W. Kohler, "The Mentality of Apes. London: Routledge & Kegan Pau,"1925.

[2] J. N. MacGregor, T. C. Ormerod, and E.P .Chronicle, "Information processing and insight: A process model of performance on the nine dot and related problems." *Journal of Experimental Psychology: Learning, Memory and Cognition*, vol. 27, pp.176–201, 2001.

[3] C. Chen and L. Duh, "Personalized web-based tutoring system based on fuzzy item response theory," *Journal of Expert Systems with Applications*, vol. 34, no.4, pp.2298-2315, 2008.

[4] Y. Lee, "Developing an efficient computational method that estimates the ability of students in a web-based learning environment," *Computers & Education*, vol. 58, no.1, pp.579-589, 2012.

[5] R. C. Clark and R. E., Mayer, "E-learning and the science of instruction: Proven guidelines for consumers and designers of multimedia learning," *Pfeiffer*, 2011.

[6] J. M. Boucheix and E. Schneider, "Static and animated presentations in learning dynamic mechanical systems," *Learning and instruction*, vol.19, no.2, pp.112-127, 2009.

[7] M. Wang, H. Jia, and V. Sugumaran, W. Ran, and J. Liao, "A web Based learning system for software test professionals," *IEEE Transactions on Education*, vol.54, no.2, pp.263-272, 2011.

[8] C. M. Chen, & T. H. Lee, "Emotion recognition and communication for reducing second-language speaking anxiety in a web-based one-to-one synchronous learning environment," *British Journal of Educational Technology*, vol. 42, no. 3, pp. 417–440, 2011.

[9] E. R. Um, H. Song, & J. Plass, "The effect of positive emotions on multimedia learning," *World Conference on Educational Multimedia, Hypermedia and Telecommunications*, Vancouver, Canada , 2007.

[10] G. J. Hwang, P. H. Wu, and C. C. Chen, "An online game approach for improving students' learning performance in web-based problem-solving activities." vol. 59, no. 4 *Computers & Education*, 2012.

[11] C. F. Lin, Y. H. Hung, and R. I. Chang, "Effect Analysis of a Multi-Material Approach to a Problem-Solving Learning System" *International Journal of Computer Trends and Technology*, vol.4, 2013.

[12] C. F. Lin, Y. H. Hung, and R. I. Chang, "Analyzing the Effects of Different Multimedia Materials on Learning System" *International Journal of Engineering Trends and Technology*, vol.4, 2013.

[13] J. Kirriemuir, & A. McFarlane, "Literature review in games and learning," Bristol, UK: Futurelab, 2004.

[14] A. Amory, "Play games to learn: Pre-service teacher development," *The Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications*, pp.2119-2118, 2011.

[15] R. E. Mayer, "The Cambridge handbook of multimedia learning," Cambridge: Cambridge University Press, 2005.

[16] T. N. Höffler, H. Prechtl, and C. Nerdel, "The influence of visual cognitive style when learning from instructional animations and static pictures," *Learning and Individual Differences*, vol. 20, no.5, pp.479-483, 2010.

[17] D. Lewalter, "Cognitive strategies for learning from static and dynamic visuals," Learning and Instruction, vol. 13, no.2, pp.177-189, 2003.

[18] G. Salomon, "Interaction of media, cognition and learning," San Francisco: Jossey Bass, 1979.

[19] R. J. Sternberg, "The nature of creativity: Contemporary psychological perspectives" CUP Archive, 1988.

[20] C. A. Wolters, P. R. Pintrich, and KS. A. arabenick, "Assessing academic self-regulated learning. Paperpresented at the conference on Indicators of Positive Development: Definitions, Measures, and Prospective Validity," Washington, DC, 2003.

[21] C. Y. Feng and M. P. Chen, "The effects of goal specificity and scaffolding on programming performance and self‐regulation in game design". *British Journal of Educational Technology*, 2013.

[22] J. Wirth, J. Künsting, and D. Leutner, "The impact of goal specificity and goal type on learning outcome and cognitive load". *Computers in Human Behavior*, vol. 25, no. 2, pp. 299–305, 2009.

[23] C. T. Chou, C. P. Chuang, & B. Y. Zheng, "The Study of Blended Learning on a Vocational High School in Taiwan". International *Journal of Modern Education and Computer Science (IJMECS*), vol. 5, no. 3, pp. 1. , 2013.

[24] B. J. Zimmerman, "Investigating Self-regulated and motivation: historical background, methodological developments, and future prospects". *American Educational Research Journal*, vol. 45, no.1, pp.166–183, 2008.

[25] D. C. Moos and R. Azevedo, "Exploring the fluctuation of motivation and use of self-regulatory processes during learning with hypermedia". *Instructional Science*, vol. 36, no. 3, pp. 203–231, 2008.

[26] C. M. Rogers, "Freedom to Learn (3rd ed.)". Ohio: Merrill, 1983.

[27] X. Yang, "The globalization and localization of "learner-centered" strategy from an international horizon." *Asian Social Science*, vol.6, no. 9, P78, 2010.

[28] J. S. Bruner, "Toward a theory of instruction." *Cambridge: Harvard University Press*, 1966.

[29] B. J. Zimmerman, "Becoming a self-regulated learner: an overview". *Theory into Practice*, *41*, 2, 64–70, 2002.

[30] G. Knoblich, S. Ohlsson, and G. E. Raney, "An eye movement study of insight problem solving". *Memory & Cognition*, vol. 29, pp.1000–1009, 2001.

[31] T. Z. Xing, "1001 Thinking games for the right and left hemispheres of the brain". He- Feng-Che –Shu-Ban Publisher, 2011a.

[32] T. Z. Xing, "1001 Thinking games for the right and left hemispheres of the brain". He- Feng-Che –Shu-Ban Publisher, 2011b.