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Game-based Learning: Students' Critical Thinking Performance while Playing "Callisto Summit"

Kung-Hou LIN [a]*, Tsung-Yen CHUANG [a] & Ju-Ling SHIH [b]
[a]*Department of Information and Learning Technology, National University of Tainan, Taiwan
[b]Graduate Institute of Network Learning Technology, National Central University, Taiwan
*Sabrinalin@tn.edu.tw

Abstract: This study investigates students' gaming decisions while playing the robotic game "Callisto Summit" and analyzes their critical thinking performance based on the gaming decisions. "Callisto Summit" is designed for the players to use block codinge to move the robots on a large game map to negotiate and solve inter-group conflicts and issues, such as city development, environmental pollution, and population. Forty-eight American students aged 8-12 participated in the game-based learning activity. In this study, qualitative research methods are used to document and observe how players made gaming decisions, then further analyze their behaviors to understand their critical thinking performance.

Keywords: game-based learning, decision making, critical thinking, robotic game

1. Introduction

Over the past few decades, global educational reform has been focused on the need of the emerging models of economic and social development to equip students with new skills and competencies included the social values and attitudes as well as with the constructive experiences. Tony Wagner (2014) asserts that the ability to think critically and solve problems, communicate effectively through speaking and writing, and collaboration with others are the top three survival skills in the 21st century. Decision-making process requires critical thinking competence, such as the ability to ask a series of good questions during the process of decision making. In general, games have great potential to support learning experiences, and Hogle (1996) showed that the benefits of games can help with learning, increase interest, provide exercise and feedback, preserve memories, as well as improve higher order thinking and reasoning skills.

Game-based learning (GBL) can provide students the opportunities for experiment and exploration. Yien et al. (2011) shows that students are more immersed in exploring the learning scenarios during the experiential activities so that they enhance learning effectiveness and get wider and deeper knowledge and skills. When the students become players in games, they explore the issues actively through interpreting information, analyzing data, implementing actions, and thinking critically for adjusting strategies to make better decisions. This study focuses on critical thinking performance and decision-making in game-based learning activity, and to demonstrate that decision making is more like an intermediary between critical thinking and problem solving.

2. Literature review

2.1 Game-based learning

Game-Based Learning (GBL) is defined as a learning strategy by Kim, Park and Baek (2009) which focuses on giving educational content through game play to reach particular objectives. With numerous studies supporting the positive effects of games on learning (Prensky, 2003), using games as a means to transfer learning content in schools and skills in workplaces has become more and more pervasive. GBL provides a challenging opportunity for players to broaden their competencies regardless of the proficiencies they began with. For instance, normally game players are repeatedly confronted with a similar type of problem at the beginning, until they find a method and master certain skills.

Moreover, game-based learning stimulates deeper thinking in players, more diversified problem solving, as well as closer teamwork through differing learning strategies and mediums than traditional classrooms (Gee, 2003). The value of game-based learning is to allow learners to be fully engaged in exploring the rules and exercisinge decision makings without taking risks in the real world. Bogost (2011) stresses that games treat topics and ideas as rules, actions, decisions and consequences, not as content to be taught. The spirit of game-based learning is allowing learning to happen in the fun process (Perrotta, Featherstone, Aston, & Houghton, 2013).

2.2 Decision Making

There are many fundamentals associated with the decision making, such as perception, resources, priority, benefits, acceptability and risks (Armistead, 2010). A better decision-making approach can help decision makers in solving problems (Mardani et al.2015). The challenge of decision-making is to maximize the value of outcomes to the decision maker and minimize the risk, which means making the most appropriate choice under an uncertain environment and in several imperfect scenarios.

Making good decisions needs competencies including personal expertise, structured high-level thinking skills, interpersonal interaction such as influence, communication, and conflict resolution skills. In fact, critical thinking improves decision making and enhances understanding of the general principles of the domain (Helsdingen, Bosch, Gog, & Van, 2010). When decision makers break down a problem according to the fact to analyze information, they are using critical thinking skills, a structured high-level thinking, to get a better decision. Clearly, critical thinking can provide the learners with a proper method to facilitate better decision making, and further to solve problems efficiently.

2.3 Critical Thinking

Critical thinking has been developing in the last 2,500 years and its definition vary. Ennis' (1996) defined it as reasonably reflective thinking that is focused on deciding what to believe and do. Scriven and Paul (1987) stated that critical thinking is the disciplined process of actively and skillfully conceptualizing, applying, analyzing, synthesizing, and evaluating information generated by observation, experience, reflection, reasoning, or communication, as a guide to belief and action. In recent years, educational reform around the world have been trended by critical thinking competences and actually has been spread from university to high school and even elementary school levels (Lipman, 1993). Critical thinking is not only memory and understanding, but also a form of higher-order cognitive processes. Students learn to use rational analysis and evaluation. Facione (2011) offered the core of critical thinking as the higher-order cognitive skills including interpretation, analysis, evaluation, inference, explanation, and self-regulation.

King (1995) and Taba (1966) suggested that students' thinking level are strongly influenced by the level of teachers' questions. Investigation of Yang et al. (2005) showed that students' critical thinking skills can be enhanced by Socratic questionings interactions between the instructors and students. The format emphasizes higher level cognitive processes, rather than asking students to remember facts and details. Socratic questions method is more likely to encourage students the analysis, synthesis, and evaluation of different sources of information. Hannel (1998) proposed seven steps to critical thinking with the information-processing steps to increase students' understanding: (1) Observation message: classification, identification (2) Looking for similarities and differences: comparison, identification of correlation, analogy (3) Identifying comprehensive topics or relationships: classification, integration, pre-summary (4) What we know: decoding, speculation (5) Correctly answering: coding (6) Applied to similar situations: inferences, plans, applications (7) What we learned: Summarize.

In this study we use the seven steps as the tool to analyze the game design and explain students' critical thinking performance in terms of their decision making processes in the game.

3. Game Design

"Callisto Summit" is a robotic game designed to embed STEM and interdisciplinary concepts. The gaming context is about Robot Beings being overpopulated in space and the base stations are in

competition for development and limited resources. Forty-eight American students aged 8-12 participated in the game-based learning activity. The students were divided into two sessions, two hours each with 24 students in each session divided into six groups.

In the game, a big map in the size of 600 x 400 cm showed the imaginary context of the planet Callisto in the 2050 (Figure1). Student groups role-play the six basic stations, including Metal, Water, Wood, Earth, Fire, and Air. Each station has different initial condition and different goals to achieve. The groups take turns to move their robots by block coding to achieve their tasks. Earth and Wood Base Stations are facing external forces for planet, development, environmental pollution, and alien trespass. Water and Metal Base Stations face economic declination and increase of chaos and safety problems due to continuous incoming robot transfers. Fire Base Station devotes in planet development which cause space pollutions. Air Base Station, in contrast, devotes to space environmental protection. The beginning set up are 7 developed areas (Red Circles), 7 adjacent polluted areas (Black Circles), 3 robot immigrants (Green Triangles), and some un-discovered areas and existing space diamonds.

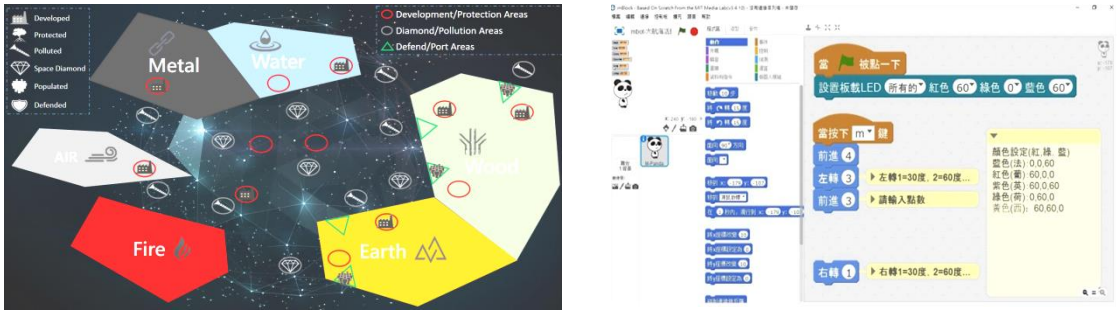

Figure 1. Map of "Callisto Summit" (left) ; the block coding software for robot action (right)

The activity starts with 5 to 10 minutes game background and rules introduction. Then all groups take 4 minutes for internal affairs to setup 3 goals in terms of the areas to move the robots to; and 4 minutes for diplomatic actions to negotiate with other groups. After then, all groups take 4 minute to write programming and 1 minutes for each group to move robots. All group do the robot movements for three rounds in a game. The whole process matches the critical thinking 7 steps (Figure 2).The winning condition is when all stations complete three tasks, and all stations are satisfied with the end results. Two games are expected for the same group of students to experiment the various gaming results that are brought about by different decision makings; and why.

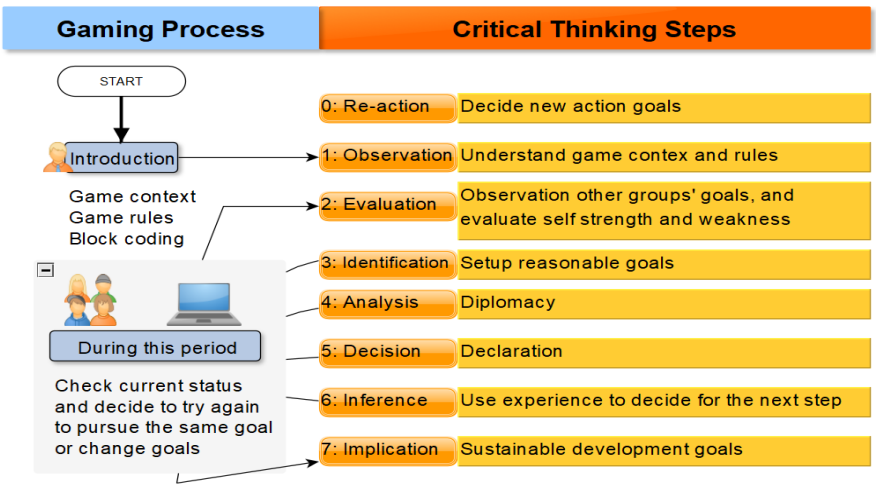

Figure 2. Gaming process with critical thinking 7 steps

The winning condition is when all stations complete three tasks, and all stations are satisfied with the end results. Two games are expected for the same group of students to experiment the various gaming results that are brought about by different decision makings; and why. All gaming movements and decision-making process are documented for analysis. After the game, evaluate the status of the planet with the students, and relate to the issues of sustainable development goals.

4. Conclusion

The study is to observe what, how, and why students would do different gaming decisions in the game. At the same time, students' coding skills and negotiating strategies will be observed to cross-analyze to identify their critical thinking performances.

Detail analysis would include how the new and better decisions can be possibly triggered by the previous action's success or failure, and how group members would affect their decisions, either by the changing conditions of the game, their sensory perceptions to the dynamic verbal or non-verbal social interactions.

Overall speaking, the students had positive feedbacks to the game. They liked the activities and they enjoyed thinking, communicating, coding in the game. They can relate what they experience in the game to the social situations in the real life. They hoped to have similar interdisciplinary activities in the future.

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