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The Effect of Digital Game-Base Learning on Primary School Students' Critical Thinking Skills and Environmental Literacy

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Abstract: Over the past few decades, many countries are doing everything they can to develop the young generation's critical and systematic thinking, to help them become independent thinkers with the capacity to engage in higher-order thinking or policy promotion. This study aims to examine the way that digital game-based learning (DGBL) exerts an effect on critical thinking and environmental literacy. The fifth-and-sixth graders will participate in the study. Participants will finish the questionnaire survey and interviewed regarding environmental protection and participants' behavior and attitudes, revealing the effect of digital game-based learning upon their critical thinking skills, and the students' environmental literacy.

Keywords: critical thinking skills, environmental literacy, digital game-based learning

1. Introduction

1.1 Motivation

Environmental issues have long been a grave concern of modern society, as the scope and variety of such problems will change as time passes. Some new issues might emerge after a period of accumulation of old issues. In Taiwan, the "go green with nuclear" initiative and the Air Pollution Control Act were recently conceived to solve the electricity and air pollution problems. Take the green-nuclear vote in 2018 as an example. Although the development of nuclear power helps to reduce air pollution and mitigate power shortage, nuclear power produces radioactive waste, which is difficult to dispose of, and the development of green energy might be neglected. As linear thinking fails to address such complicated problems, many countries are doing everything they can to develop the younger generation's critical and systematic thinking, to help them become independent thinkers with the capacity to engage in higher-order or critical thinking. This has become an important agenda for most advanced countries. Environmental education offers opportunities to consider these issues and try to present possible solutions to many heated disputes. Thus, students learn to examine current conditions from a more diversified perspective.

Technological advances have contributed to the spread of digital education. Compared with traditional classroom-based teaching, the advantage of digital learning is its lack of temporal-spatial constraints. Take the Taiwan Environmental Information Association for example. As the largest environmental information media, it holds contests employing children's picture books or games, with the hope of helping players come to realize the importance of environmental education; most of these are card games or board games. Some researchers argue that by introducing digital games into the classroom, learners may be more motivated, willing to cope with challenges and resolve problems at hand. This study intends to use digital games as a medium, in order that students may learn to collect and analyze information, while actively exercising their judgment and reasoning skills. All this may hopefully increase young learners' critical thinking and reasoning skills, as well as their environmental literacy. In terms of the importance of critical thinking in education, this study proffers a research study plan with relevant literature on how to use DGBL as a strategy to improve students' environmental literacy and critical thinking skills. In addition, this study intends to explore the efficacy in using simulations of environmental episodes in game-based learning to develop students' mastery of critical

thinking and achieve better environmental literacy, and determine whether they will continue to put their enthusiasm and sense of participation in environmental protection into practice in their life after the course ends.

2. Literature review

Environmental education

How humans interact with the environment is an issue that needs to be addressed by the whole world. When modern people formed an awareness of environmental issues decades ago, they started to see the importance of environmental education and related issues, and decided to think of ways to preserve the natural environment's sustainability into the future. The dissemination of environmental education and related issues started in the 1970s when international communities took initiatives to promote a series of actions. UNESCO presented the Declaration of Tbilisi in 1977, whereby the role and objectives of environmental education were put into a complete context (Karama, 2016). The above Declaration proffered a number of key points as follows: 1.To help learners identify the real causes underlying environmental issues. 2. To stress the complexity of environmental issues, and the need to develop the younger generations' ability to engage in critical thinking and employ problem-solving skills. 3. To employ a diversified learning environment and wide range of teaching strategies in environmental education. 4. To inspire learners to exert their abilities when they are immersed in a learning experience, and take responsibility for their decision-making outcomes. Taylor (1985) explored ways of game simulation in an instructional setting aimed at environmental education in order to simplify actual situations while still presenting the complexity of real environmental problems. Meanwhile, the discussions, Q&As, and role-playing may all help to improve students' environmental literacy because they tend to exercise stronger participation when told stories that occurred in the real world (Arslan, Moseley & Cigdemoglu, 2011). Considering that teaching methods are associated with learners' level of participation, we employed various learning strategies to help them better immerse in the scenarios (in which current events happening in Taiwan will be described), to which they are exposed via games. During the process, teachers may encourage them to weigh in different factors and values by asking questions. This helps to enhance their critical thinking skills and problem-solving strategies regarding environmental issues.

Previous studies regarding game-based learning and critical thinking skills

In the education field, the development of game-based learning has so far shown a certain positive effect in keeping students motivated in their learning process. Norman (2014) indicates that games help to achieve the basic requirements of, and add fascinating elements to, a learning setting. When it comes to environmental education, we may take advantage of game-playing that is both educational and entertaining to increase motivation in learners. Currently, relatively few domestic and foreign studies have been dedicated to exploring the correlation between digital games as a learning aid and environmental literacy. In the Literature Review section, a few research papers are cited for discussion on the relationship between game-based learning and one's higher-order thinking ability. They include Sousa and Rocha's (2019) study on the virtual world created by games that might develop and increase the leadership skills possessed by players. Also, Lee et al.'s (2016) study focuses on company executives' decision-making capabilities, as these gamers need to analyze and conjecture the real meanings beneath a large amount of conflicting and contradictory messages within a company.

As the games mentioned in the above literature combine scenarios and question-asking strategies to inspire learners to think, it is clear that "questions" are the starting point of the critical thinking process. According to Hsu and Wang (2018), the act of forming questions cannot direct learners to achieve further understanding, but may help them to partake in analyzing the learning content and form basic concepts in their minds, while integrating these messages when doing so. The design of games involves a mechanism of opposites, so that students may learn to develop a range of abilities, including analytical, integrational, and assessing skills via the mechanisms of challenges and interactions, and ultimately learn to be critical thinkers who know how to solve problems, and become enthusiastic learners with high motivation.

What is critical thinking?

Since its inception, the development of "critical thinking" has undergone several phases; a large number of scholars have proffered very different ideas and rationales for it because critical thinking involves philosophy and psychology, two different academic disciplines (Ab Kadir, 2017). Yet some similarities can still be found in these academic explorations. The first scholar who presented a definition of "critical thinking" was Glaser (1941); he suggested three attributes for critical thinking: 1. A tendency to consider issues and solve problems. 2. Having an understanding of rational exploration and logical reasoning. 3. Having the skills to employ the above-mentioned strategies. Afterward, the American Philosophical Association developed the Delphi method, and declared: "We believe critical thinking is a purpose-oriented, self-regulated judgment, which involves an objective judgment by a series of steps: interpretation, analysis, evaluation, estimation, and explaining a matter from a variety of factors related to evidence, concepts, methodologies, standards, and background information" (Facione, 1990). Of these, the six core critical thinking skills are: inference, explanation, evaluation, self-regulation, interpretation, and analysis (Facione, 1992).

From the above literature, it is clear that a majority of scholars are convinced that developing critical thinking means one has the ability to discover and clarify a problem, to form a judgment of messages and conduct self-regulation. Also, it is vital that one be sure of one's hypothesis-forming process and learn to reflect on the hypothesis and convictions in the process (Braman, 1999). The capacity to reflect on, and regulate, one's own thinking is the key to forming higher-order thinking and developing critical thinking. In other words, it is reflection, not judgment, that makes it possible to perform a "rational analysis", develop the ability for "logical reasoning", and ultimately "make assessments and judgments" during the process. Some studies also reveal the importance of self-regulation and reflective judgment in developing critical thinking, as these would determine an individual's evaluation (Dwyer, Hogan & Stewart, 2015). Some researchers believe that the cultivation of critical thinking involves the development of skills and images, constantly asking questions, reflecting, regulating, and learning to examine one's reflection process. This also helps to maintain higher-order thinking, which aids in clarifying a problem and rectifying it.

3. Research methodology

This study explores Taiwan's environmental education by employing critical thinking strategies and digital game-based learning methods. Previous literature has shown that games are beneficial in breaking free of temporal-spatial constraints in order to help learners immediately experience the environmental problems. The fifth-and-sixth graders of a primary school located in Southern Taiwan were used as the research subjects in this study, while some "protection areas" were used in the game design. The game was designed from the angle of animals, so students might be able to interpret environmental issues from different perspectives, such as survival and data collection, and gain an opportunity to think about the environmental issues in a critical way.

Gamers were given a world view, a description of stories, and an explanation of questions before they started the game. This helped gamers to take on missions in the context of the story. The question design was coupled with assessment tools for critical thinking. The environmental issues included the conservation of indigenous species, pollution, and pesticide sprays. Thus, learners learned to consider and identify the complexity of environmental issues. Although surveys and evaluation tools compiled by domestic and foreign scholars are numerous, they cannot be readily added into our survey because of socio-cultural barriers and gaps in translation (Kuo, 2008). To help learners better understand the questions, the game was designed in accordance with the "first-level critical thinking" developed by Taiwanese scholars, in the hope of achieving a more satisfactory outcome in evaluating the environmental literacy of these young respondents in Taiwan (Yeh, 2003).

Furthermore, it is advised to design the evaluation scale in accordance with the syllabus of the 12-year Basic Education, to thoroughly evaluate students' awareness, comprehension, system of values, skills, and practices regarding environmental protection. The core competencies comprise "systematic thinking and problem- solving" and "moral practices and civic consciousness" (Ministry of Education, 2014). All of the above indicate that a curriculum with environmental issues added may lead to a

transfer of learning, which proves helpful to increase awareness of environmental protection as well as critical thinking habits. Therefore, it is advised to provide a questionnaire survey and interviews regarding environmental protection and participants' behavior and attitudes before and after the course, thus revealing the effect of digital game-base learning upon the critical thinking skills, and the students' environmental literacy. The experimental procedures are illustrated in Fig 1.

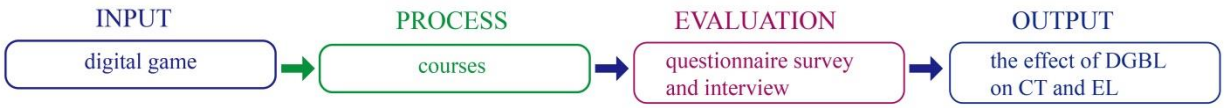

Figure 1. The experimental procedures.

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