A Project entitled

Assessing the ecological card game "Geopardized Ecosystem" as a teaching aid for fostering geographical enquiry skills

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Declaration

I, Wu Hin Ting declare that this research report represents my own work under the supervision of Dr. Wong Kwan Lam Gwendolyn, and that it has not been submitted previously for examination to any tertiary institution.

Signed

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1 April 2021

Abstract

"Geopardized Ecosystem" is a card game designed to teach secondary school students the concepts of ecosystems. It challenges players to contemplate the inter-relationship of organisms in the ecosystem. This paper elucidates the application of the card game in classroom teaching. The design and concepts behind "Geopardized Ecosystem" are described alongside the compatibility in the Hong Kong Diploma of Secondary Education Examination (HKDSE) curriculum. A brief account of the Play Curricular Activity Reflection Discussion (PCaRD) model is provided. The levels of thinking in the revised Bloom's Taxonomy (Anderson & Krathwohl, 2001) are placed in juxtaposition with the geographical enquiry skills embedded in the Geography Curriculum and Assessment Guide (Secondary 4 – 6) (2017).

One study was carried out to explore the effectiveness of using the card game as a teaching aid. Pre-test and post-test were administered to gauge students' achievement in geographical enquiry skills after the intervention. Mixed results were demonstrated. The quantitative result indicated an overall improvement in the experimental group in contrast to the stagnant result of the control group. In particular, significant improvement was demonstrated in Higher Order Thinking skills for the experimental group. Mild differences were observed in the qualitative data, with the experimental group achieving better results.

The results are discussed in accordance with the role of the card game in maximizing the learning gains and the acquisition of geographical enquiry skills. Implications for teaching and design of games for learning are explained.

Keywords: Higher Order Thinking skills, Geography, Game-based learning, Bloom's Taxonomy

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Introduction

"Geopardized Ecosystem" is an ecological card game I designed a few years ago in the hope of engaging my future Geography students. It emanated from the fundamental concepts of ecosystems, which are embedded in one of the Hong Kong Diploma of Secondary Education (HKDSE) Geography modules (Disappearing green canopy — Who should pay for the massive deforestation in rainforest regions?).

Geographical enquiry skill is imperative as stated in the Geography Curriculum and Assessment Guide (Secondary 4 – 6) (The Education Bureau HKSAR, 2017) It is, therefore, worth shedding light on inquiry-based learning approaches that can enhance students' enquiry skills, such as Game-Based Learning (GBL). (Hwang, Chiu, & Chen, 2015). The Play Curricular activity Reflection Discussion (PCaRD) pedagogical model is implemented in this study as it was proven to be efficacious in conducting GBL. (Denham, 2019).

This study has the following research objective:

- Evaluate the card game "Geopardized Ecosystem" in fostering students' geographical enquiry skills when coupled with the PCaRD model.

The prerequisites of the card game being used in the educational setting are the relevance to the curriculum. Thereby, a section for assessing the level of alignment of "Geopardized Ecosystem" with the module "Disappearing green canopy — Who should pay for the massive deforestation in rainforest regions?" is included in the Game Introduction Section.

"Do not, then, my friend, keep children to their studies by compulsion but by play."

— Plato (427–347 BC)

Brief background

This research adopts the model of Play Curricular activity Reflection Discussion (PCaRD) within the Game Network Analysis (GaNA) suggested by Aroutis N. Foster (2015). The model aims to integrate digital games in the classroom for maximizing the benefits of play-based learning. A detailed description of the model is provided in the next session. Digital games had gained its prominence with the heated STEAM education trend. Yet, a printed card game retains its traditional advantages of easy access and low cost."Geopardized Ecosystem", as all other educational card games, provides means to apply game-based pedagogies in an instructional space that lacks technology. The PCaRD model was deliberately chosen for its meticulous design in implementation supported by previous experiments. It will be applied as a tool to configure the pedagogies in this study for fair comparison and future replication.

The PCaRD model explained

The PCaRD model was one of the three overlapping areas in the Game Network Analysis (GaNA). It overlaps the TPACK (Technological, Pedagogical, Content and Knowledge) circle and the ICCE (Inquiry, Communication, Construction and Expression) circle. The former shed light on the role of teacher in transmission of knowledge, while the latter places emphasis on the knowledge acquisition by students. The PCaRD model leverages on both areas in bridging the gap of teaching and learning. With the printed card game, "Geopardized" in this study, technology in the TPACK plays a less significant role. It, nevertheless, will not impede the any procedure in the study. Game analysis, an overlapping part of PCaRD with TPACK, is essential to facilitate quality teaching. In addition, the overlapping of PCaRD with ICCE gives rise to the quintessence of this study, the integration of game.

The Game Network Analysis framework

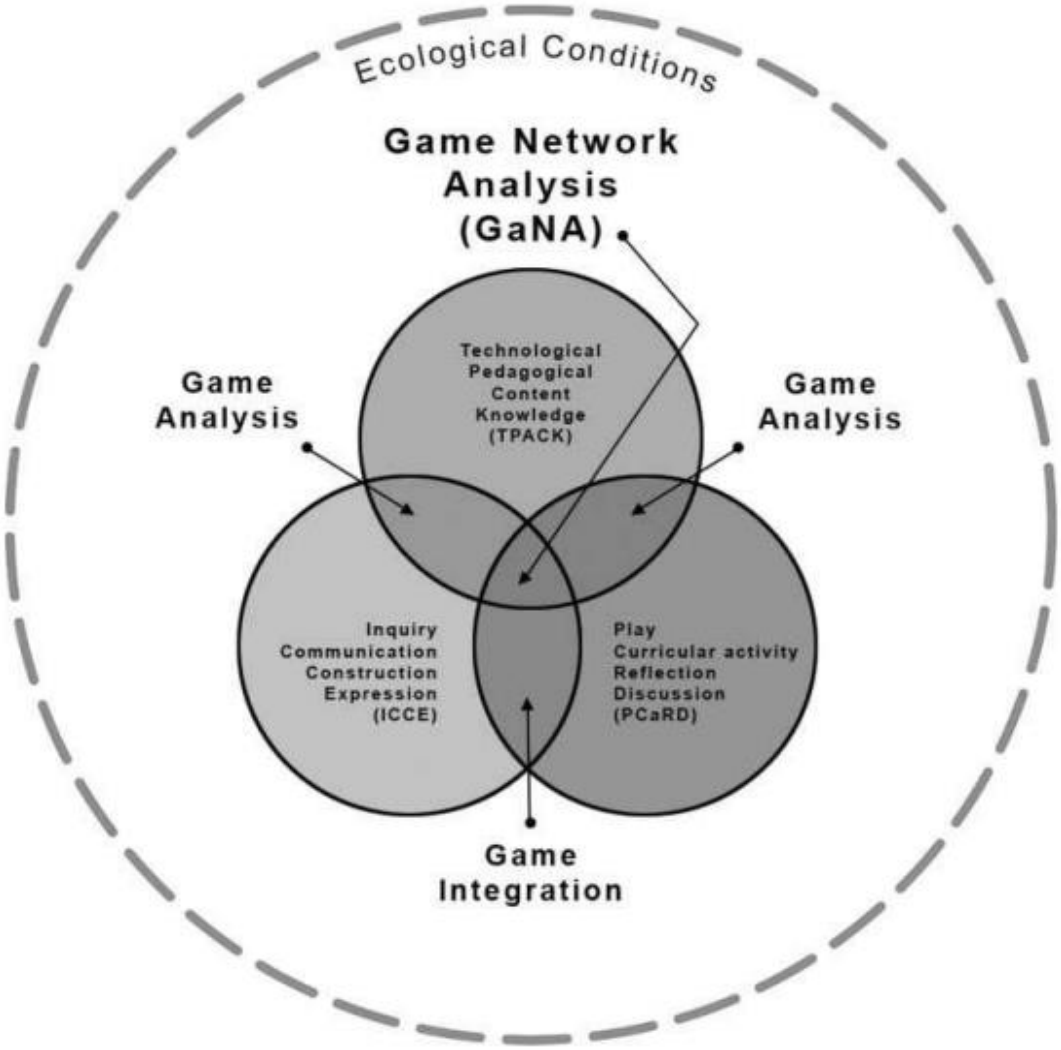


Figure 1: The Game Network Analysis framework

Source: Foster, A., & Shah, M. (2015). The Play Curricular Activity Reflection Discussion Model for Game-Based Learning. Journal of Research on Technology in Education, 47(2), 71-88.

The implementation of the PCaRD model

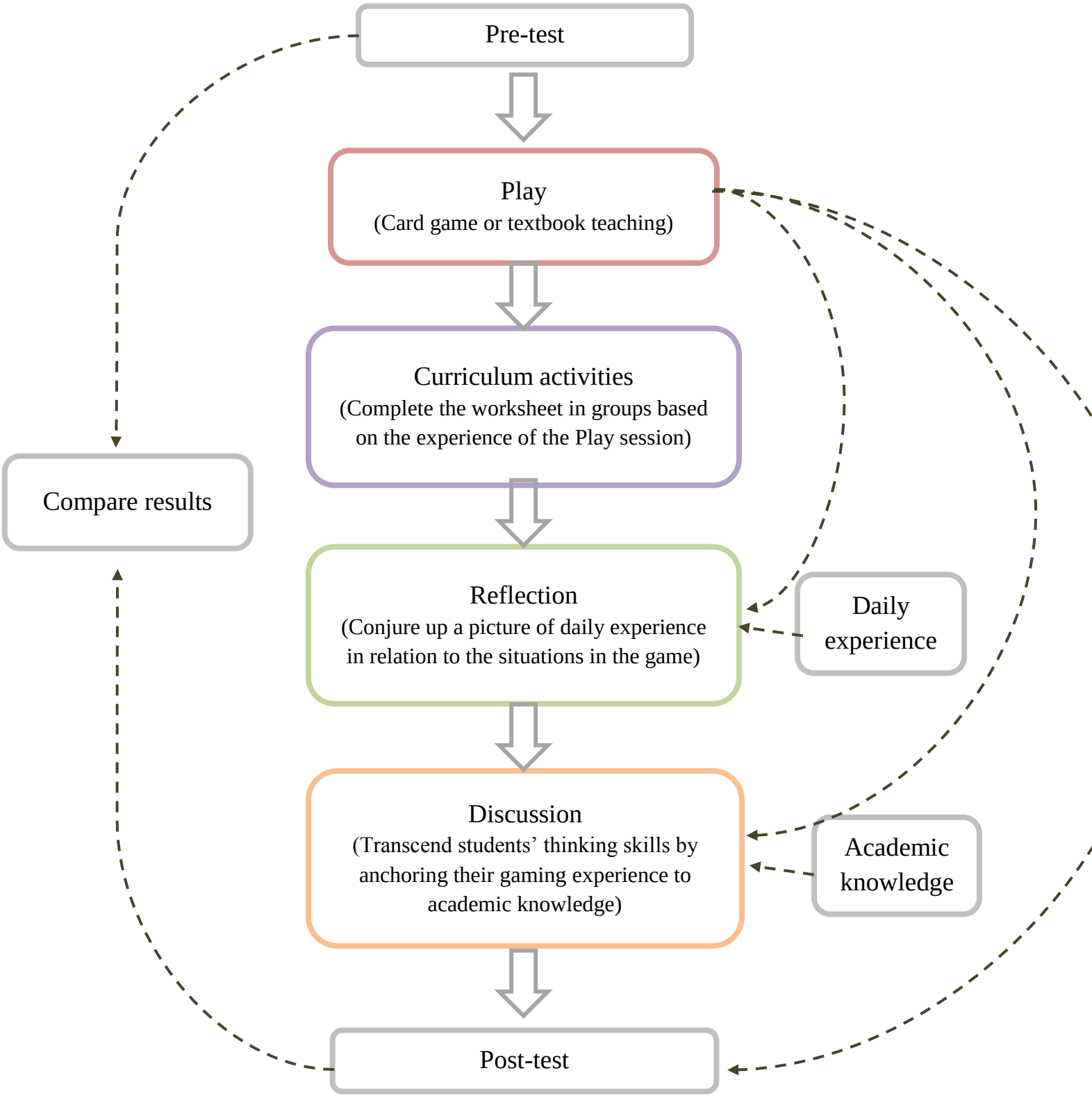
The PCaRD model consists of mainly four components, including Play, Curriculum activities, Reflection and Discussion. Play comes first in the model indicating its pivotal role. Students are expected to engage in gameplay for approximately half an hour depending on the complexity of the game. Within this period, they are on their own to explore the game without any interventions from the teacher.

Followed by Play, is the Curriculum activities deciphering the game-play experience and knowledge. Teachers' knowledge of the game is valued as much as students' experience as they both are the anchor for developing problem-based activities. These series of activities provide students with the opportunities for inquiry, communication, construction and expression (ICCE). It is expected to last for twenty to thirty minutes.

Next comes the Reflection session for consolidating the knowledge gained. Students are encouraged to interact with their peers to facilitate the merging of personal experience, knowledge and game experience. They will be allowed to articulate their experience and thoughts or write them down depending on the pedagogical decisions of the teacher. It usually lasts for fifteen to twenty minutes.

Last but not least, a fifteen to twenty minutes discussion session led by teachers will help transcend students' thinking skills. They are encouraged to seek explanations to their questions, relate their game experience to the academic knowledge and express their opinions.

Diagram detailing the flow of the study



Geographical enquiry skills

Developing students' geographical enquiry skills is part of the curriculum objective in the Geography Curriculum and Assessment Guide (Secondary 4 – 6) (2017). It consists of a variety of skills ranging from identification to evaluation which can correlate to the various levels in Bloom's revised taxonomy (Anderson & Krathwohl, 2001). Table 1 lists the geographical enquiry skills in the curriculum guide in relation to the levels in Bloom's Taxonomy and the components in the PCaRD model.

Geographical inquiry skills	Level in Revised Bloom's Taxonomy	Steps in the PCaRD model
Identify and ask questions from a geographical perspective	Remember	Play
Locate, select and extract appropriate information and data	Understand	Play
Present and organise information and data	Apply	Curricular activities (ICCE)
Compare, analyse and synthesise	Analyse	Reflection
Evaluate the findings, solutions or conclusions	Evaluate	Discussion

Table 1: Summary of the geographical enquiry skills with Revised Bloom's Taxonomy (Anderson & Krathwohl, 2001) and the PCaRD model (Foster & Shah, 2015)

Literature review

Studies in the field of education psychology had shed lights on the correlation of emotions with motivation and academic performance. Specific feelings arise from educational contexts are coined academic emotions (Schutz & Perkrun, 2007). It is often differentiated into two common types, the positive emotions like joy and hope, the negative type such as anxiety and boredom. Positive emotions are positively correlated to students' motivation and academic achievement (Pekrun et al., 2002).

Students who find enjoyment in performing academic tasks are regarded as having intrinsic motivation. Intrinsic motivation has been proven to boost academic outcomes within the motivational framework proposed by Ryan & Deci (2002). The coalescence of the findings by Pekrun (2002) and Ryan & Deci (2002) had completed the loop of the interrelationships of emotions and academic outcomes. In brief, an effective teaching aid which can arouse positive emotions will motivate students intrinsically, hence boosting their academic achievement.

Play-based learning in enhancing students' learning

Play-based pedagogies had received more attention in recent years alongside the surging interest in the integration of digital games. To ensure effective teaching with games, research had been done to investigate the efficacy of play-based pedagogies. It is widely recognized that there is a need for a pedagogical model for effective implementation of games to guide teachers' intervention and assist in students' learning. (Gros, 2010; Ketelhut & Schifter, 2011) In addition, the foundation of educational design introduced by Sørensen (2011) encompasses crystal clear learning objectives, concise cropping of the content area, detailed planning and well-organised learning processes.

Cicchino (2015) attempted to examine the correlation of Game-Based Learning (GBL) with critical thinking employing both quantitative and qualitative methods. Critical thinking, defined by Moon's (2008), involves complex cognitive skills including analysis, interpretation and evaluation. Cicchino (2015) interpreted the lack of significant improvement in test scores as the failure of accommodating game-based teaching in traditional classrooms. A note to make here is the other possible factors accounting for the absence of difference including the pedagogical

decisions and the choice of games which will be further explained in the later parts. On the contrary, qualitative data had shown positive results. These data involved the tape recordings of students' conversation during the game. Researchers had pinpointed insightful dialogues which they believed to be mirroring the critical thinking process. These qualitative data, however, was not supported by the quantitative ones giving readers the room for doubts.

It is not a novel idea to study the efficacy of games in fostering certain skills in students. Similar studies had been done to assess the capability of games in boosting Higher-Order Thinking (HOT) skills. Melville et al. (2018) indicated that the game "Building Baterial Knowledge" resulted in the greatest learning gains when coupled with a reflection session in contrast to the game being used alone or being replaced by a formal lecture. The positive results in the study corroborate the validity of games as teaching aid in fostering HOT skills. As the HOT skills bear some resemblance with the geographical enquiry skills, it can be hypothesized that games are effective in fostering students' geographical enquiry skills. The lack of details about the reflection activities, however, has hindered the reliability. Discrepancies in pedagogical decisions may also affect the overall performance of the game in teaching. Hence, it is necessary to adopt a refined model for harnessing other variables.

The effectiveness of PCaRD model in game-based leaning

A comprehensive model for GBL is paramount for deciphering students' playing and learning experience. Foster & Shah (2015) reported a positive result with the implementation of the PCaRD model in a high school in America. Twenty-one out of twenty-five ninth-grade students completed the Game-Based Learning course for supporting learning in mathematics and science. The quantitative data collected is highly valid provided the teacher-researcher partnership in setting the assessments and formulating lesson plans. The contrasting quantitative results with the game "Dimension M" and "Physicus" in knowledge gain and intrinsic motivation (IM) highlighted the game as one of the determining variables. Both studies, however, gave positive results in terms of qualitative data, proving it to be successful in facilitating students' knowledge construction. Yet, the reliability of the result is questionable as the study was carried out in a specifically arranged year-long course. It can be a quite different matter when the model is implemented in the traditional

classroom. The ample extraneous variables, such as the discrepancies in students' ability to learn and the aforementioned pedagogical decision might have weakened the validity.

The case study conducted by Denham (2019) on the teachers' perception of the PCaRD model provided insights on the barricades of implementation in a formal classroom setting. Time management and the need to alter lesson plans are reported as the main challenges. The PCaRD model was applied in Mathematics class in middle schools by three teachers respectively. Resonating with the results generated by Foster & Shah (2015), teachers had expressed their amusement on the conspicuous improvement in students who traditionally lagged behind. Denham (2019) recorded teachers' general positive perception on the model but frustration to varying extends when applying it. Although teachers believed the incorporation of the model had positively impacted the summative assessment results, they stated the need for adjustments in response to the class composition.

Majority of the studies had underscored the efficacy of the PCaRD model on various levels ranging from knowledge acquisition to increased motivation. Although the outcomes varied based on the teachers' knowledge of the game and their pedagogical decisions, it is relatively constant in enhancing students' learning gains. This sets the stage for assessing the effectiveness of "Geopardized Ecosystem" with the PCaRD model.

Research gap

Skills, knowledge and attitudes build the foundation of all curriculums. Knowledge gain and changes in attitudes are often studied, but skills acquisition is always overlooked. The effect on students' disciplinary skills development with the implementation of the Play Curricular Activity Reflection Discussion (PCaRD) model had not been investigated. On top of that, the PCaRD had not been applied to Geography lessons. This model provides the lens for evaluating the effectiveness of the geographical card game "Geopardized Ecosystem" in fostering students' geographical enquiry skills.

It is also with much concern that most of the relevant studies were done in the Western world where the education system is considerably different from that of Asian. The implementation of the model in the context of Hong Kong is thereby worth analysing. Nevertheless, applying the model in the formal education system can be met with foreseeable challenges ranging from larger class size and less flexible teaching schedule.

This study focuses on the research question:

- To what extent can "Geopardized Ecosystem" foster students' geographical enquiry skills with the adoption of the Play Curricular activity Reflection Discussion (PCaRD) pedagogical model?

Research methodology

This study aims at assessing the card game "Geopardized Ecosystem" in fostering students' geographical enquiry skills. Teacher-oriented action research within the branch of teacher research will be applied to investigate the effect of interventions on students' learning gains. Before and after study design can precisely capture the effect of the intervention, which in this case, is the instruction. The effects of extraneous variables such as the students' academic ability and gender will be minimized by keeping the distribution of academic ranking and gender ratio approximately the same in each group. The Play Curricular activity Reflection Discussion (PCaRD) model is applied to minimize the variations in pedagogical decisions.

Hypothesis

- Incorporating "Geopardized Ecosystem" in the PCaRD model would result in greater learning gains than replacing the "Play" with textbook teaching.

Assumption:

The implementation of the card game "Geopardized Ecosystem" will facilitate the geographical enquiry skills of students which can be reflected upon the post-test results.

(a) Game design, overview and structure

(i) Design overview

"Geopardized Ecosystem" was designed to facilitate the understanding of the inter-relationship of the biotic elements in the ecosystem. Its approaches can be understood with the Mechanics, Dynamics & Aesthetics (MDA) Framework (Hunicke, LeBlanc & Zubek, 2004). The MDA Framework provides the "lens" to understand the causally linked component of the game. (LeBlanc, 2004)

Mechanics, dynamics and aesthetics correspond to the rules, systems and "fun" of the game respectively.

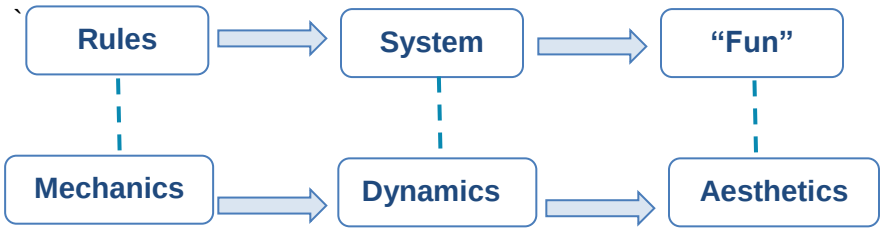


Figure 2: The MDA framework

Source: Hunicke, Robin & Leblanc, Marc & Zubek, Robert. (2004). MDA: A Formal Approach to Game Design and Game Research. AAAI Workshop - Technical Report. 1.

The food chain in various natural habitats is the core mechanics underlying the game. Through feeding on other organisms in lower trophic levels, the cycle of life is completed. The participants are required to "preserve" (collect) the entire food chain against all odds. There may be unanticipated events like deforestation that can sabotage their rescue mission. On the contrary, performing environmentally-friendly actions reward the participants with an extra opportunity to exchange their hand cards.

The choices made by a participant may generate direct impacts on others via two dynamic systems. The first one is the choice of the food chain. A package contains only one copy of each food chain meaning that choosing the same food chain as another player will impede one's chance of winning. The second dynamic is the effect of "function cards", namely the "Destruction card" and the

"Action card". Intrinsically, participants will preclude others from completing their chosen food chain by using the "Destruction cards" while maximizing their chances to succeed by the "Action cards". Externalities of the destructive behaviours, such as the removal of the desired organisms, will be experienced by players.

According to Robin Hunicke, Marc LeBlanc and Robert Zubek (2004), there are eight taxonomies (Eg. Sensation, fantasy, narrative, etc.) when describing the aesthetic of the game. "Geopardized Ecosystem" can be regarded as the "Fellowship: Game as a social framework" as it aims to provoke thoughts on the consequences of our behaviours. It mirrors the reality of society and human nature.

(ii) The structure of the game

The game consists of five independent food chains in respective habitats and biotic components ranging from decomposers, producers, primary consumers to secondary consumers. The players will compete to be the first one to collect all four of the components in a food chain. The wise use of the "Destruction card" and "Action Card" will give players a leg up in the game, like prohibiting others from getting the desired card to complete the food chain. The rules (mechanics) of the game are rooted in the concept of the ecosystem, such as the predator and prey relationship. Cards are exchanged based on the natural principle of trophic levels. Detailed instructions are provided in the Appendix.

Figure 3: The food chains of "Geopardized Ecosystem"

(iii) Assessing the alignment of “Geopardized Ecosystem" with the HKDSE syllabus

Curriculum, instruction and assessment are three associated components in education. The instruction, which refers to the teaching materials and the choice of pedagogies, has to be built on the curriculum.

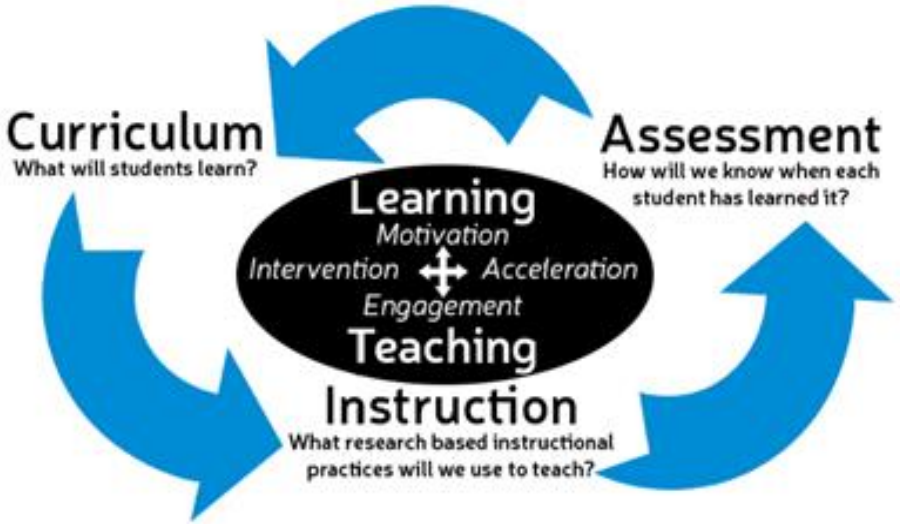


Figure 4: The model of curriculum, assessment, and instruction. (Cedar Grove High School, 2020) Retrieved from: https://www.cgschools.org/curriculum/

It is only compelling for teachers to conduct game-based teaching when the game aligns perfectly with the curriculum. Therefore, the level of alignment of “Geopardized Ecosystem” with the HKDSE Geography curriculum in terms of knowledge, skills and attitudes is scrutinized in Table 2. Most of the items in Table 2 can be taught with the help of the card game, thus, the level of alignment is relatively high.

	Knowledge (concepts)	Skills	Attitudes
The HKDSE Geography curriculum (Module 6 relative to the part of the ecosystem)	Ecosystem Abiotic and biotic components Spatial association Ecological equilibrium Energy flow Nutrient cycling Human interference Scale of development	1. Use graphic representation to show the interrelationships between abiotic and biotic components. 2. Extract relevant information from photos and pictures. 3. Roleplay: How different parties can develop the potential of tropical rainforests.	1. Appreciate the interdependence of human beings and the natural environment 2. Show concern for the problems caused by deforestation 3. Develop a sense of responsibility and willingness to take action in protecting the tropical rainforests

Table 2: The content of HKDSE Geography Module 6 categorized by skills, knowledge and attitudes.

*Content highlighted in yellow represents the existing elements in "Geopardized Ecosystem".

**Content highlighted in orange represents the elements included in the intervention (classroom instructions).

(b) Method

Both quantitative and qualitative data were collected from the experiments. Quantitative data involves the pre-test and post-test scores. Test scores, nonetheless, may not be a comprehensive indicator on the depth of learning given the complexity of the skills. To augment the reliability of the results, qualitative data is mandatory for a thorough analysis of students' learning gains. Qualitative data comprise the students' written reflection in the Reflection sessions.

One study was conducted to cover the research questions. The study aims at investigating the learning gains of students with "Geopardized Ecosystem" incorporated into the PCaRD model and it being replaced by textbook teaching respectively. It comprised of 12 Form 6 secondary school students assigned to Group A and B. The gender ratio, distribution of academic ability and age were kept approximately the same in each group.

The quantitative data was then triangulated with qualitative data of students' written reflection. Methodological triangulation across methods was applied to reduce biases and deficiencies. The qualitative data collected clarified and augmented the quantitative data by providing detailed insights. Rubrics for assessing students' skills acquisition was established for sorting the qualitative data in correspondence to the various levels of thinking.

Participants

The participants of the studies consisted of 12 Form 6 secondary school students taking Geography as their elective subject. Each group consisted of 6 students with a gender ratio of approximately 1:1.

Procedures

The class time in each period was rather limited in formal education, thus, the experiment was divided into three sessions within the same week. Pre-test and post-test were carried out before and after the intervention.

The study	Session 1		Session 2		Session 3	
	20 min	40 min	20 min	20 min	20 min	20 min
	In person	In groups for Group A In person for Group B	In groups	In person	In groups	In person
Group A	Pre-test	Play (using the card game)	Curricular activities	Reflection	Discussion	Post-test
Group B		Textbook teaching				

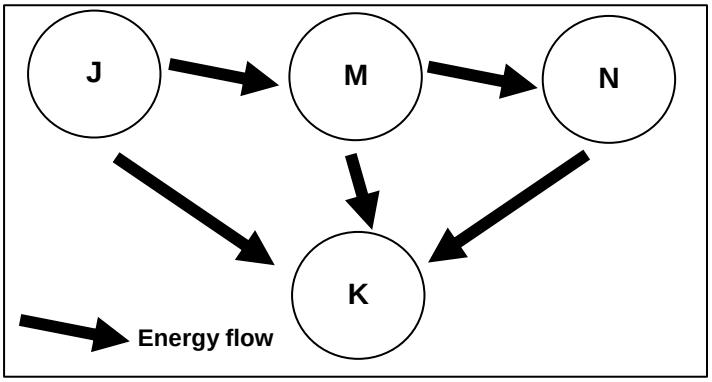
Table 3: Procedures of the study

(c) Measures

Anchored to the geographical enquiry skills listed in the Geography Curriculum and Assessment Guide (Secondary 4 – 6) (2017), the acquisition of the skills can be reflected by one's ability to remember, understand, apply, analyze and evaluate. That being said, a test assessing the skills mentioned above can mirror the acquisition of the geographical enquiry skills to a large extent.

Both pre-test and pro-test consist of the same set of questions but in random order. A test with 8 multiple choice questions and 1 short question was designed. To increase the validity and reliability of the tests, questions from the DSE Geography exam were adopted with mild modifications. The exam reports and curriculum framework were consulted to justify the sorting of questions into various levels in the Anderson & Krathwohl (2001) Revised Bloom's Taxonomy. The acquisition of each skill will be reflected upon the percentage scored by students in each level.

All questions address the basic knowledge in the module and the geographical enquiry skills ranging from remembering, understanding, applying, analyzing to evaluating.

<table>
<tr><th>Levels in revised Blooms Taxonomy</th><th>Examples of questions (The draft assessment is provided in the Appendix)</th></tr>
<tr><td>Remember</td><td>Which of the following is an abiotic component?
a) Fungi
b) Algae
c) Soil
d) Krill</td></tr>
<tr><td>Understand</td><td>Which of the following statement about the ecosystem is true?
a) An ecosystem is a community of living organisms in conjunction with the nonliving components of their environment
b) Only some species have an important role in each community
c) Humans are not part of ecosystems
d) Plants that grow in a certain area will not affect the survival of other plants and/or animals</td></tr>
<tr><td>Apply</td><td>Refer to the figure of a food chain below.
 

Which of the following is the correct labelling of the above figure?
<table><tr><th></th><th>J</th><th>K</th><th>M</th><th>N</th></tr><tr><td>A</td><td>Decomposer</td><td>Producer</td><td>Secondary consumer</td><td>Primary consumer</td></tr></table></td></tr>
</table>

	B	Secondary consumer	Primary consumer	Decomposer	Producer
	C	Producer	Decomposer	Primary consumer	Secondary consumer
	D	Primary consumer	Secondary consumer	Producer	Decomposer
Analyse	Refer to Figure 1a. Explain the impact of the human activities in Table 2a on the nutrient cycle shown in Figure 1b.				
Evaluate	*'Rainforest adoption'* aims at inviting the public to buy rainforest land for conservation. Evaluate whether 'rainforest adoption' can effectively conserve the rainforest ecosystem.				

Table 4: Examples of assessment questions

Ethical considerations

This study involves human as test subjects, hence informed consent and voluntary participation are necessary. Form 5 to Form 6 students usually aged 16 to 18, so parental consent is not required according to University's Human Research Ethics Committee (HREC). Consent forms will be distributed to all the participants stating the objectives of the study and promising the careful handling of sensitive information, such as names and test scores. The personally identifiable data will be kept confidential and stored only in sealed devices. It will be removed when publishing the results in the final report. This study will not do any physical nor psychological harm to the participants.

Result

The participants were first separated into two groups according to their gender. Then, students were sorted into Group A and Group B alternatively in the order of their class numbers. For example, the male student with the smallest class number was allocated to Group A and the second smallest to Group B. The same was performed for the female group. Yet, the average Geography score of Group A (the experimental group) in the previous semester was significantly higher than that of Group B (the control group). (Table 5) The total score of the subject (Geography) is 100. A difference of 8.66 in the average score of the two groups was found. In contrast to this preconception, however, Group B showcased a better performance (a 10.3/18 average) compared to Group A (a 9.4/18 average) in the pre-test. The total score of both the pre-test and post-test is 18.

Average Geography score		Median Geography score	
Group A	Group B	Group A	Group B
48.26	39.6	48.6	39.75

Table 5: Geography scores of participants in the previous academic year

Greater increase in the post-test score in the experimental group

From the data collected, there was a 2.2 increase in the average score in the post-test, from 8.9 to 11.1 in general. (Table 6) However, when the results are analysed concerning the experimental and control groups, only Group A yielded an increased post-test score. The mean score of Group A showcased a 2.6 increase on average, from 9.4 to 12, while Group B's score remained stagnant at 10.3. (Table 7) The mean score of Group A increased from 52.2% to 66.7% while Group B remained at 57%. A conspicuous 14.5% increase in score testified Group A as the pivotal agent in raising the general test scores.

student no.	pre-test result	post-test result
1	8	12
2	9	13
3	8	12
4	9	11
8	13	12
5	8	14
6	10	13
7	9	9
9	11	7
10	5	9
11	8	10
Average	8.91	11.09

Table 6: Test scores of all participants

Pre test mean score		Post test mean score	
Group A	Group B	Group A	Group B
9.4	10.33	12	10.33
52.22%	57.41%	66.67%	57.41%

Table 7: Average test scores of Group A and Group B

Discrepancies in questions required Lower Order Thinking and Higher Order Thinking Skills

Based on Bloom's Taxonomy, there are six levels of learning ranging from remembering to creating. The hierarchical model can be roughly split into the upper and lower half, with the former representing higher-order thinking skills and the latter the lower-order thinking skills. To place the Blooms' Taxonomy in juxtaposition with the steps in the PCaRD model (Table 1), the lower half is further divided into two parts, (1) remember and understand, (2) apply. The "Play" in the model is responsible for the lowest levels "Remember and understand" while the "Curricular Activities" is responsible for the lower median level "Apply".

Group A had shown no improvement in the lowest levels "Remember and understand" with a mean score of 5.8/6. In contrast, a mild decline was observed in Group B, dropping from 4.3/6 to 4.2/6. When converting the scores into percentage, Group A scored an average of 96.7% and Group B 71.7% in pre-test. Regarding the post-test, Group A showed stagnant result while Group B dropped slightly to 70%.

The mean score of Group A again remained stagnant the "Apply" level with a score of 2.6/4 (65%). The mean score of Group B, however, had climbed from 2.3/4 (57.5%) to 2.8/4 (70%), surpassing that of Group A in the post-test.

Combining the results of the "Remember and understand" level with "Apply" level as Lower Order Thinking skills had allowed for simpler interpretation. Group A scored 8.4/10 (84%) in both pre-test and post-test and Group B 6.66/10 (66.6%) in pre-test and 7/10 (70%) in post-test. A mild 3.4% increase in Group B is translated to a gentle improvement in the Lower Order Thinking Skills.

A significant increase in the mean score at the "Analyse and evaluation" category was observed in both groups, with Group A a greater increase. The mean score of Group A increased from 1/8 (12.5%) to 3.6/8 (45%). The increase in Group B was less salient, from a mean score of 1.8/8 (23%) to 3.3/8 (42%). It fell behind that of Group B in the post-test. The increase in Group A is 32.5%, in contrast to the 18.75% in Group B.

Experiment group	Remember and understand		Apply		Analyse and evaluate	
	Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test
A	6	6	2	2	0	4
A	6	6	2	3	1	4
A	6	6	2	3	0	3
A	5	5	4	3	0	3
A	6	6	3	2	4	4
B	5	4	3	4	0	6
B	3	3	3	4	4	6
B	5	3	2	2	2	4
B	5	4	3	3	3	0
B	3	6	2	2	0	1
B	5	5	1	2	2	3
Average	5	4.90	2.45	2.73	1.45	3.45
Group A average:	5.8	5.8	2.6	2.6	1	3.6
Group B average:	4.33	4.17	2.33	2.83	1.83	3.33
Total score in each part	6		4		8	

Table 8: Test scores of all participants in relation to the various levels in Bloom's Taxonomy

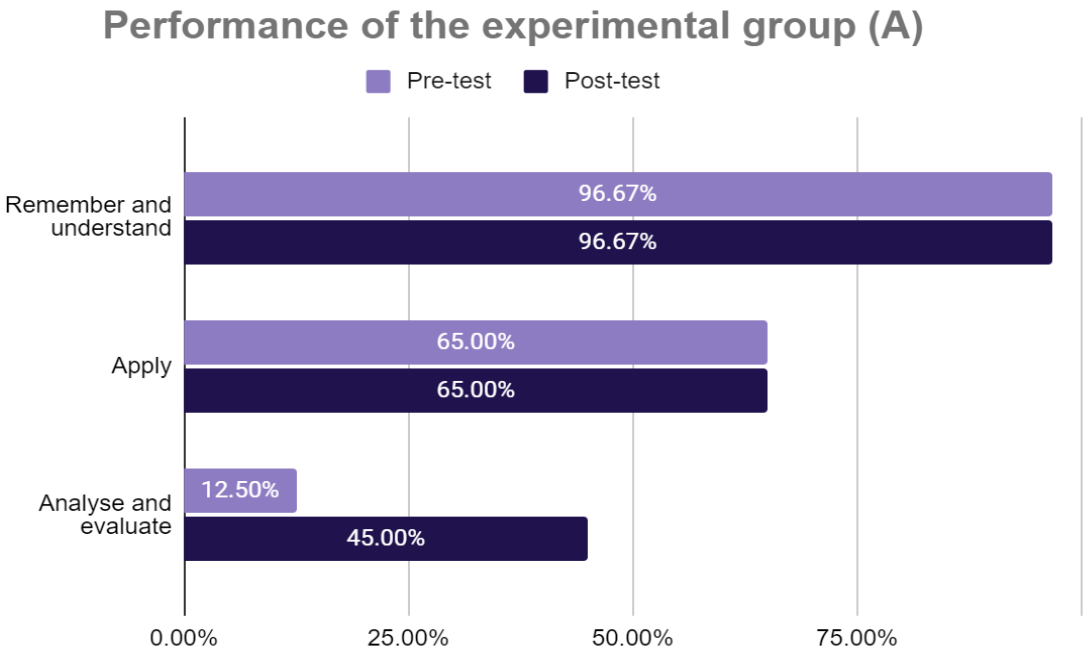


Figure 5: Percentage changes in the experimental group in different level of thinking skills

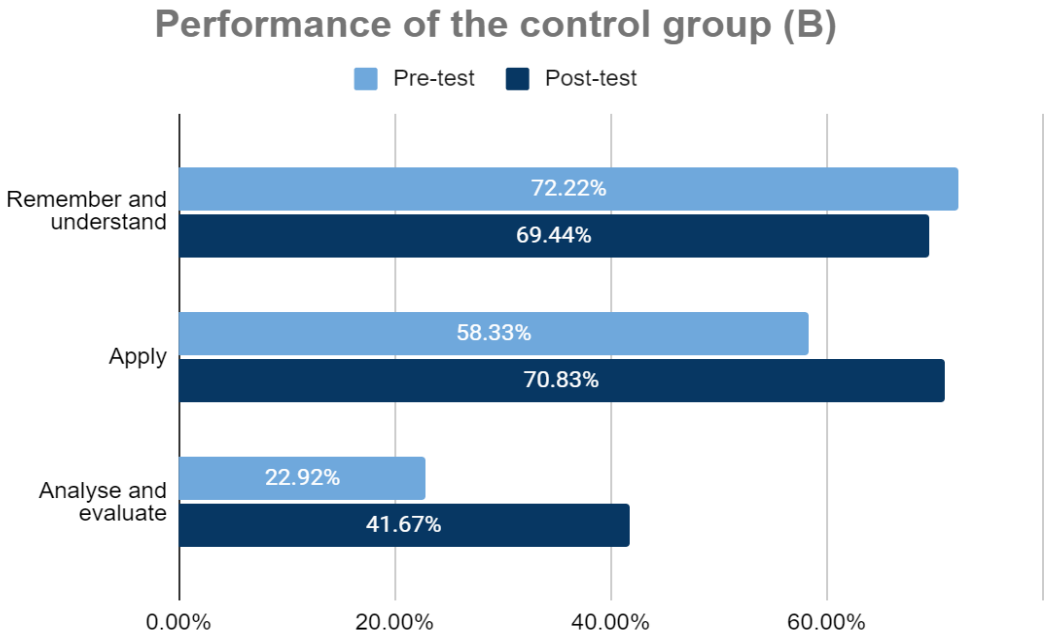


Figure 6: Percentage changes in the control group in different level of thinking skills

Experiment group	Remember, understand and apply (LOT)		Analyse and evaluate (HOT)	
	Pre-test	Post-test	Pre-test	Post-test
Group A average:	8.4	8.4	1	3.6
Group B average:	6.66	7	1.83	3.33
Total score in each part	10		8	

Table 9: Test scores of both groups in relation to Lower Order Thinking skills and Higher Order Thinking skills

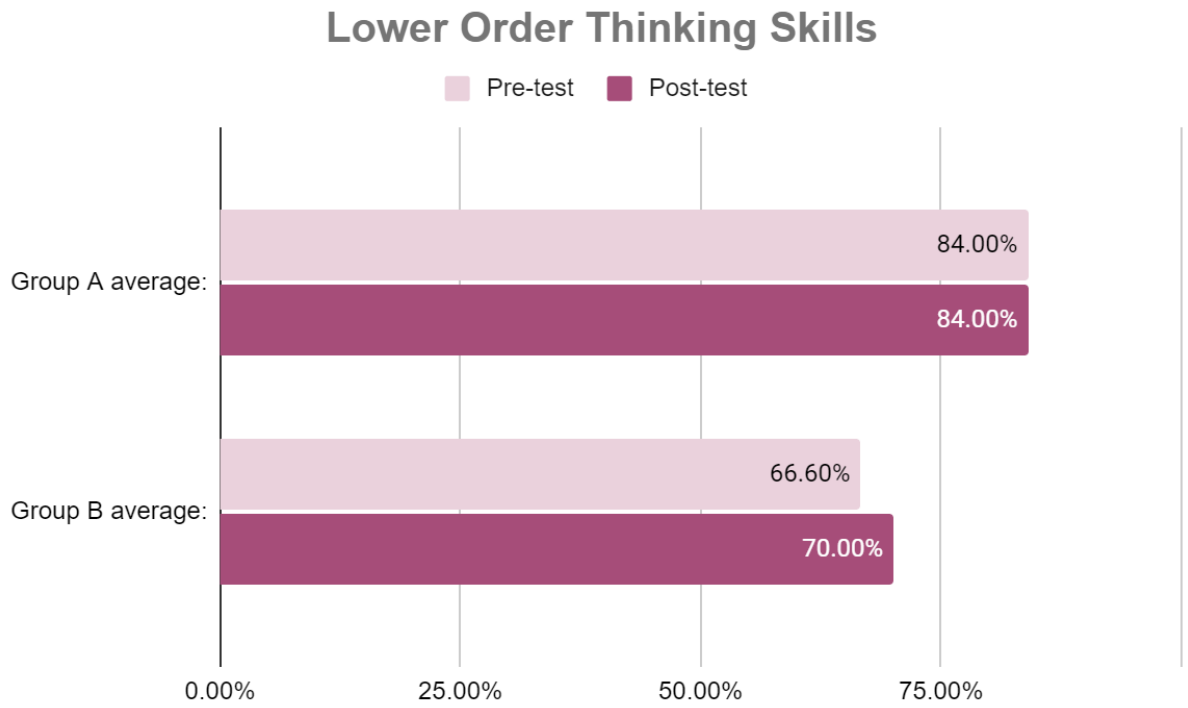


Table 10: Percentage changes in the Lower Order Thinking skills in both groups

Question types impose limited effects on the result

Two types of question were used in the assessment to better gauge the learning gain of students. Multiple-choice questions are a more convenient measuring tool. It eliminates the issue of failure to express ones' though given his limited language ability. Yet, it also poses the danger of getting the right answer by chance. The short question in the assessment was therefore put in place to fill the gap. In general, the results concerning each type of questions tallied with the results sorted according to the level of thinking. The score of the post-test demonstrated a 0.36/8 (4.5%) increase in the MC section and a 1.82/10 (18.2%) increase in the short question on average. Language ability plays a less significant role in this assessment as students' learning gains can be reflected in both the multiple-choice and short questions. It is of paramount importance to reiterate that both the multiple-choice and short questions cover a variety of thinking skills. This ensures the result can reflect students' learning gains regardless of their language or writing ability.

MC (8 marks)		SQ (10 marks)	
Pre test	Post test	Pre test	Post test
6	6	2	6
6	7	3	6
6	7	2	5
8	7	1	4
7	6	6	6
5	7	5	6
6	4	3	5
6	6	2	8
6	6	5	1
3	6	2	3
4	5	4	5
5.73	6.09	3.18	5

Table 11: Test scores in relation to the types of questions

The results of Group A when taken apart are less straightforward. The performance of the multiple-choice questions remained stagnant while that of the short question leapt 2.8/10 (28%) to 5.4/10 (54%). The multiple-choice questions cover thinking skills like remembering, understanding and applying. These are regarded as lower-order thinking skills in Bloom's Taxonomy. The short questions, in contrast, covers mostly the analyzing and evaluation skills. A total of eight marks are allocated to questions that required these skills, and merely two marks are contributed by the skill of understanding. This result corroborates with the result when analyzed under the level of thinking. Besides, the significant rise of 2.6 marks (26%) in the short question further put to rest the doubts of students' language ability in affecting the results.

Group A			
MC (8 marks)		SQ (10 marks)	
Pre test	Post test	Pre test	Post test
6	6	2	6
6	7	3	6
6	7	2	5
8	7	1	4
7	6	6	6
6.6	6.6	2.8	5.4
Group B			
MC (8 marks)		SQ (10 marks)	
Pre test	Post test	Pre test	Post test
5	7	5	6
6	4	3	5
6	6	2	8
6	6	5	1
3	6	2	3
4	5	4	5
5	5.67	3.5	4.67

Table 12: Test scores in relation to the types of questions in Group A and B respectively

The results of Group B indicated improvement in both the multiple-choice and short question sections. There is a mild improvement of a 0.67 mark (8.4%) increase in the multiple-choice part and a salient increase of 1.67 (16.7%) mark in the short question. Nevertheless, the increase in the short questions is much less than that of Group A.

Qualitative data from students' written reflection

The qualitative data collected in students' written reflection corroborates with the quantitative data. Question 4 and 5 were selected from the Reflection worksheet for Group A, while question 2 and 5 were selected for Group B. Question 4 in Group B's worksheet was discarded given its confusion and hence replaced with question 2 in the analysis.

In Group A's worksheet, question 4 is classified as the "Analyse" level and question 5 as the "Evaluation" level. Similarly, in Group B's worksheet, question 2 is regarded as the "Analyse" level while question 5 the "Evaluation" level. The rubrics for the Reflection worksheet is provided in Appendix (vi). Students' answers are classified into three categories, including "unattained"(U), "developing"(D) and "accomplished"(A). (Table 13) Answers marked "Accomplished" is regarded as evidence of the acquisition of a specific level of skills. Answers in different levels were extracted as samples in accordance with the description in the rubric. (Appendix (vii))

Students no. 12 was absent for the pre-test, hence contributed merely to the qualitative data.

student no.	Analysis level	Evaluation level	Experiment group
1	D	**A**	A
2	**A**	**A**	A
3	U	U	A
4	U	**A**	A
8	U	D	A
12*	U	**A**	A
5	U	U	B
6	D	U	B
7	U	**A**	B
9	D	D	B
10	D	**A**	B
11	D	**A**	B

Table 13: Performance of all participants in the Reflection worksheet

On the analysis level, Group A ostensibly performed better than Group B. The answer of student no. 2, who belong to Group A, was the only one marked "accomplished". However, the students who are believed to be "developing" the analysis skills in Group B out-competed Group A significantly. Four students were "developing" the skills in Group B contrasting the merely one student in Group A. The sample answer marked "Accomplished" in this level had reflected the student's ability to relate the subtle message from the card game to reality. The ability to correlate concepts is as strong as evidence of analytical skills.

"It symbolised the impact of human activities on the food chain. People destroy the natural environment for their interest, which is a selfish act."

On the evaluation level, Group A again performed better than Group B. Four students' answers in Group A attained the "Evaluation" level in contrast to three in Group B. Both groups include one student who was "developing" the skill. In general, the attainment of this level of thinking was evidenced in detailed and structured answers. An example is taken from Group A' worksheet marked "Accomplished" demonstrated the students' ability to perceive the core message of the card game and reflected upon the examples emanated from it.

"Yes, the card game informs the players once the destruction card is used, the food chain will suffer. It portrays the destructive acts in real life. For example in terms of dietary, people prey on a kind of organism for food lavishly, upsetting the balance of the ecosystem."

Discussion

This study attempts to shed light on the effectiveness of incorporating the card game "Geopardized Ecosystem" in enhancing Geographical enquiry skills. The PCaRD model was implemented to harness the myriad extraneous variables. With positive results from studying the application of the model (Foster & Shah, 2015), focus can be diverted to the effectiveness of the card game.

Higher learning gains in the experimental group

The significantly higher learning gains of the experimental group (Group A) in contrast to the control group (Group B) had supported the hypothesis of "Incorporating "Geopardized Ecosystem" in the PCaRD model would result in greater learning gains than replacing the "Play" with textbook teaching." This discrepancy in learning gains was more salient in the quantitative result, supporting the effectiveness of the card game "Geopardized Ecosystem" in facilitating students' construction of Geographical enquiry skills in general.

Significant improvement in Higher Order Thinking skills in the experimental group

Categorizing the questions into various levels in Bloom's Taxonomy had provided more insights into the level of thinking attained by students. The questions were separated into three main categories, with analytical and evaluation skills topping the pyramid as the Higher Order Thinking Skills. The conspicuous improvement in this category corroborated the study conducted by Melville et al. (2018) that applying games as a teaching aid could foster the HOT skills. This study had confirmed his observation that the game provided the greatest learning gains when coupled with a reflection session to it being replaced by formal lectures, in other words, direct instruction. It is worth noting that the significant improvement in the application skills in the control group heralded the value of direct instruction to some extent. No clear explanation, however, can be provided at this stage in justifying the worsened performance on the "Remember and understand" level in the control group.

Stagnation in Lower Order Thinking Skills in the experimental group

The score in Lower Order Thinking Skills, including remembering, understanding and applying, remained the same in the experimental group. This can partly be attributed to the variance in the pedagogy. Replacing the textbook teaching session with card game means less emphasis placed on rote learning. Instead of memorizing the keywords and graphics on textbooks, students were encouraged to make meaningful connections between their prior knowledge. They do not simply "know" some facts but were able to make sense of them through engaging in the game play.

Triangulating the qualitative result with the quantitative result had validated the positive result. Students in the experimental group demonstrated a stronger ability in mastering the HOT skills in the chosen questions, rendering support to the quantitative result.

In response to the research question, the result had testified the efficacy of "Geopardized Ecosystem" in fostering students' specific geographical enquiry skills. The inquiry skills requiring HOT skills, including (1) Compare, analyse and synthesise and (2) Evaluate the findings, solutions or conclusions, were best cultivated with the implementation of the card game.

The card game as the fundamental building block

When applying the PCaRD model, the sessions were laid out in scaffolding in accordance with the level of thinking. The implementation of the card game was responsible directly for the first and foremost session "Play". However, in the diagram detailing the flow of the study, all the ensuing sessions had to draw on experiences from the "Play" session. The improved performance in the HOT skills had augmented the effectiveness of the "Reflection" and "Discussion" sessions. As these two ensuing sessions were built upon the game experience, the enhanced acquisition of the HOT skills can be accrued to the incorporation of the card game.

This observation had raised an intriguing question on the sequence of skills acquisition. Must students master the LOT skills to gain better access to the HOT skills? Bloom et al. (1956) explained that the mastery of the lower-level skills is a prerequisite to achieving the higher categories. He believed a student must first acquire knowledge before more complex thinking takes place. The result of this study does not refute Bloom's (1956) point of view but casts doubts on the word "mastery". Clarification on the phrase "mastery the lower-level skills" are essential before testifying the argument. Apparently, the experimental group in this study achieved a mediocre result in the "Apply" level but excelled in the "Remember and understand" category. Yet, significant improvements in the HOT skills (analyse and evaluate) were exhibited in the experimental group.

Positive emotions in boosting performance

The overall better performance of the experimental group can be explained by the positive emotions arose in the playing process. As elucidated in the study conducted by Pekrun et al., (2002), positive emotions are positively correlated to students' motivation and academic achievement. Drawing from the findings by Pekrun (2002) and Ryan & Deci (2002), an educational setting which can arouse positive emotions will motivate students intrinsically, hence boosting their academic achievement. The educational setting in the experimental group involved using the card game, in contrast to the control group using textbook. The difference in the educational setting can account for the variance of results through examining students' psychological state. More qualitative data, however, are required to better gauge the students' emotion during the study.

Limitations and recommendation for future study

Due to the limited resources in this study, the study covered a small scope with limited samples. The results do not represent the general population since the experiment was conducted merely in one Band 3 secondary school in Hong Kong. The banding of the school influences the results in terms of students' ability and motivation. Inevitably, extraneous variables in experimental design cannot be entirely eliminated. A tedious deviation from the result will be expected if the experiment is replicated in the future.

Besides, The Play Curricular activity Reflection Discussion (PCaRD) model is originally designed for incorporating digital games, hence, a gap existed when coupled with printed card games. With that in mind, the teaching materials used in the study were tailored to fulfill the aim of each step in the model. In terms of the assessments, multiple-choice and short questions are convenient and the most straightforward. However, the acquisition of some geographical enquiry skills cannot be fully reflected through merely two types of questions. Hence, the mixed approach adopted in this research helps fill the gaps. All in all, this study had offered teachers new perspectives on incorporating games into teaching in a formal classroom setting in Hong Kong.

Future study

This study consists of a small pool of participants all from the same Band 3 secondary school. More diversified participants are required to testify the effectiveness of the card game. And a larger number of participants is necessary to validate the results. If the experiment is replicated on a larger scale, a distribution curve can be run on the test scores in respective experimental group. The distribution curve in pre-test can be compared with the post-test of the same group. The peak of the normal distribution curve in both groups is expected to shift to the right according to the hypothesis in this study. On the other hand, the distribution curve of post-test in one group can be compared to that in another group. The experimental group is expected to demonstrate a curve with higher peak approaching the right end.

Besides, qualitative data measuring emotions students experienced during the study can be collected through questionnaire or focus group interviews. For example, two students will be invited from each experimental group for an interview of 10 minutes. Questions surrounding their personal feelings and the learning atmospheres will be asked. This may provide researchers with more data to elaborate the discrepancies in the results.

Implications

This study had demonstrated the feasibility of implementing GBL in formal Asian education. With limited class time and a tight teaching schedule, especially during the outbreak of the pandemic, the study was slightly improvised. Despite a little cut in the time for some steps, the scaffolding of the pedagogies was not compromised. Incorporating the card game into the PCaRD model provides a comprehensive understanding of play-based pedagogies. There were lurking presumptions of play-based teaching being less time-effective. As the amount of time spent on both the experimental and control groups was the same, the higher achievement of the experimental group has proved otherwise. On top of that, this study provides new insights on assessing card games or other educational games. Synergy of the chosen game and pedagogy fosters students' skills acquisition but not simply knowledge gain or motivation. After all, this experiment sets an example of teaching geographical concepts and skills through tailored card games, providing teachers with an alternative in pedagogies.

Conclusion

"Geopardized Ecosystem" was designed to convey the message of environmental protection. It is expected to inspire secondary school students to contemplate the consequences of human activities on nature. This study has provided empirical evidence supporting the effectiveness of "Geopardized Ecosystem" in fostering students' thinking skills. The acquisition of the geographical enquiry skills through the card game provides incentive for educators to use it in teaching. To reiterate the purpose of this study, it boils down to an indication that playing and learning are inseparable. To break free from the shackles of conventional pedagogies requires one to be creative and bold. It is also worth noting the value of human interactions in this technology-driven world. Digital games cannot replace paper-based games entirely given its lack of face-to-

face communication. All in all, there is no one size fits all solution when it comes to teaching. Any pedagogies can be deemed appropriate and effective in certain situations.

Direction for further study

To convince teachers to substitute textbook-based teaching with game-based teaching may be unrealistic and farfetched. There are intrinsic values in pedagogies involving the use of textbooks. These values should not be overlooked. The reasons that refrain teachers from using game-based pedagogies, however, are often the huge consumption of time and unfavourable school policies. Circumstances allowing game-based pedagogies to bear fruit are to be discovered and so are the ways to overcome the traditional classroom constraints. Going down that path, studies on the effect of teacher training on implementing game-based pedagogies are necessary given game-based teaching is worth promoting.

Acknowledgement

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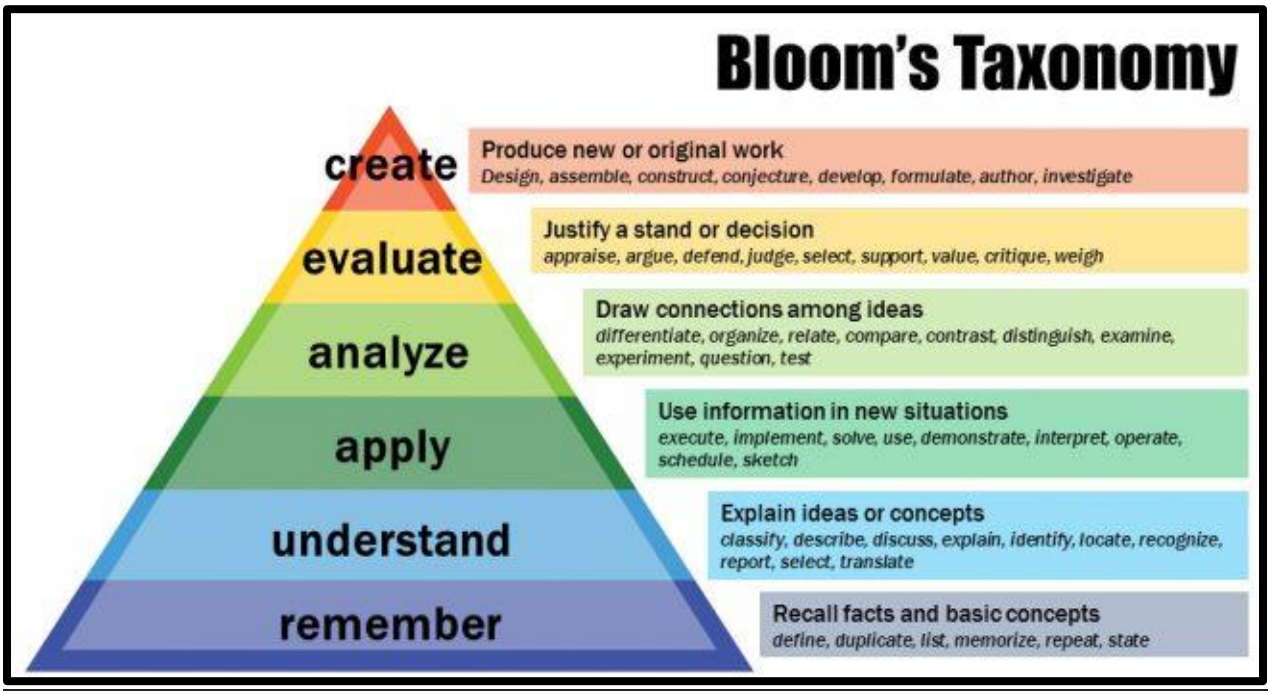
Appendix

(i) The geographical enquiry skills

(a) geographical enquiry skills, including the ability to:
  (i) identify and ask questions from a geographical perspective;
  (ii) locate, select and extract appropriate information and data from primary and secondary sources (e.g. the field, surveys, documents, maps, charts, ground and aerial photos and Geographic Information System [GIS] data), which require the ability to observe and record data systematically and accurately;
  (iii) present and organise information and data, which involves the ability to:
    – use appropriate techniques for summarising (e.g. descriptive statistics such as measures of central tendency and variability);
    – use appropriate formats, such as texts (e.g. reports, tables, summaries, etc.) and illustrations (such as maps, diagrams, models, sketches, and graphs);
  (iv) compare, analyse, synthesise and evaluate, in order to interpret information and data for making inferences and drawing conclusions, which includes:
    – the use of appropriate statistical techniques (e.g. correlation);
    – analysis of spatial patterns using GIS.
  (v) evaluate the findings, solutions or conclusions drawn from enquiry.

Geography Curriculum and Assessment Guide (Secondary 4 – 6) 2014, the Education Bureau HKSAR. Retrieved from http://334.edb.hkedcity.net/doc/eng/curriculum/Geog%20C&A%20Guide_updated_e.pdf

(ii) Revised Bloom's Taxonomy



Revised Bloom's Taxonomy (Anderson & Krathwohl, 2001). Retrieved from https://cft.vanderbilt.edu/guides-sub-pages/blooms-taxonomy/

(iii) Lesson plans and teaching resources

The appendix (iii) was deleted by the author.

(iv) Pre-test and post-test

The appendix (iv) was deleted by the author.

(v) "Geopardized Ecosystem" Instructions

The appendix (v) was deleted by the author.

(vi) Rubrics for Question (4) & (5) in the Curricular Activities

	Question	Unattained	Developing	Accomplished
Analysis	Group A Question 4	Correlation unexplained	Established a vague correlation with insufficient explanation	Established a sound correlation supported by concrete examples
	Group B Question 2	Correlation unexplained	Established vague correlation between human activities and the disappearance of the tropical rain forest	Provided concrete examples to justify the rate of disappearance of the tropical rain forest
Evaluation	Group A Question 5	Fail to conceive any messages from the card game	Presented a situation in real life emanate from some aspects of the card game with insufficient elaboration	Provided real-life examples to reflect on and able to retrieve the core message of the card game
	Group B Question 5	Fail to elaboration on the example	Provided an example without justification in respect to the economic and environmental aspects	Assessed an example in balancing the economic and environmental aspects

(vii) Students' answer in accordance to the rubrics

	Question	Unattained	Developing	Accomplished
Analysis	Group A Question 4	Correlation unexplained *"Human activities"*	Established a vague correlation with insufficient explanation *"The destruction card symbolised a food chain being irreversibly detroyed"*	Established a sound correlation supported by concrete examples *"It symbolised the impact of human activities on the food chain. People destroy the natural environment for their own interest, which is a selfish act."*
	Group B Question 2	Correlation unexplained *(no example available as both participants left it blank)*	Established vague correlation between human activities and the disappearance of the tropical rain forest *"Overgrazing and deforestation had resulted in the reduction of forests."*	Provided concrete examples to justify the rate of disappearance of the tropical rain forest *(no example available as no participants attained this level)*
Evaluation	Group A Question 5	Fail to conceive any messages from the card game *"Yes, like deforestation."*	Presented a situation in real life emanate from some aspects of the card game with insufficient elaboration *"Yes, the destruction card symbolise the human activities like cattle ranching, hunting and urban encroachment."*	Provided real-life examples to reflect on and able to retrieve the core message of the card game *"Yes, the card game informs the players once the destruction card is used, the food chain will suffer. It portrays the destructive acts in real life. For example in terms of dietary, people prey on a kind of organism for food lavishly, upsetting the balance of the ecosystem."*
	Group B Question 5	Fail to elaboration on the example *"The locals were more concern than the government in protecting the natural environment."*	Provided an example without justification in respect to the economic and environmental aspects *"Endeavor to develope ecotourism to reduce the burden of human consumption on the natural resources."*	Assessed an example in balancing the economic and environmental aspects *"We may enact laws to restrict the number of trees being chopped. Policies can be implemented to provide the locals with jobs to protect the local environment and prohibit illegal logging."*