A Project entitled

The optimal implementation of game elements in geographical education: a comparison on traditional pedagogy, gamification, and game-based learning.

Submitted by

Lo On Ki

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Abstract

Gaming in education can stimulate students' engagement and subsequent learning outcomes while scientific research claims that its effectiveness fluctuates with variables, like participant' age and nature of subject matter. The linkage between secondary geographical education and game element implementation is still an open question. Aiming to find some insights in this issue, this study has investigated the effectiveness of different game pedagogies on students' learning outcomes. Experimental lessons with 71 secondary three students were conducted. Students were randomly assigned to experience one of the three pedagogies in learning the theme – national cooperation for climate change. Pedagogies include traditional pedagogy, gamification, and game-based learning. We have found evidence that students' learning motivation increases with increasing game elements, but no regular relationship was found in terms of cognitive learning outcomes. Our results indicate that the effect of games may depend on game design. A mixed pedagogical approach is suggested to maximise both students' motivational and cognitive learning outcomes in geography class.

Declaration

I, Lo On Ki declare that this research report represents my own work under the supervision of Title and Name of Project Supervisor, and that it has not been submitted previously for examination to any tertiary institution.

Signed: _____

(Lo On Ki)

4/4/2022

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1. Introduction

Effective learning is hidden by various factors nowadays. Geography teachers are concerned about reaching teaching schedules under Hong Kong's fully packed and exam-oriented education system, resulting in standardized and boring classes. Understandably, students are lost in learning, serving it as a burden. Students become low motivated, resulting in low efficacy of geography learning. A vicis cycle occurred in unengaged classes when the bustle geography teacher left students with half-formed concepts. However, learning is a student's duty, whilst getting students to learn is the teacher's role. Student low engagement is widely admitted as a pressing issue by hiding the potential achievement of sound academic learning outcomes (Lee & Hammer, 2011; Ryan & Deci, 2009). To address the problem, arousing students' interests is a prominent key in promoting effective learning. Engaging in gaming in class may have remarkable motivational power by acting as a stimulator in raising the interest in geography concepts.

1.1 Overview of geographical education

Geography is a study of human-environmental relationships on places and locations from local to global scales. To be specific, learners initially understand the Earth’s diversity with the formation of places and landscapes before investigating interactions between humans and nature. Eventually, they could establish a holistic view on the impacts of human spatial decisions, as well as the interconnected mosaic of cultures and societies (CGE, 1992). In geography education, students are equipped with the knowledge, skills, and attitudes to practice reasonable decisions for the planet in changing times (Chang & Kidman, 2019; Tan & Chang, 2008). In terms of skills, spatial thinking skills and geographical inquiry skills are the main focus. Learners are expected to seek solutions to human and physical geography problems through a series of geographical processes (Artvinli 2020). In terms of value, a sense of geographical dimension is fostered.

1.2 Overview of Gamification

Gaming raises engagement based on a series of design principles and processes used to motivate individuals in driving behaviours and desired outcomes (Wang, 2011). Individuals enjoy gaming, despite facing challenges with negative feelings that are unavoidable. The application of game design elements in non-game activities, such as education, known as Gamification (Al-Faliti & Al-Blushi, 2016; Rouse & The University of Southern Mississippi, 2013). Gaming is identified as a tool in shaping classrooms to be living game spaces (Al-Azawi, Al-Faliti & Al-Blushi, 2016; Hamari, Koivisto & Sarsa, 2014). Students learn under free-choice and free-to-fail circumstances through completing missions given. The ultimate aim is to engage students in learning in a supportive environment. Gamified education may create favorable conditions for teaching and learning effectively.

1.3 Overview of Game-based Learning

Game-based learning is a pedagogy that integrates subject matter and game elements according to students' capacity. Learning goals, curriculum needs, and educational psychology have to be considered in pedagogy design. Game rules, mission, and enjoyment are some illustrations of game design (Mz & Sy, 2008). Students apply knowledge learned through gaming in the real world (Team, Editorial, 2017). Game-based learning consists of three principles that are (1) competition between teacher and students or students themselves; (2) engagement of students due to curiosity and interest, and (3) immediate rewards like descriptive feedback given by teachers and marks awarded based on achievements (Wang, n.d.). In application, game-based learning consists of two approaches which are digital game-based learning and non-digital-based learning. Even though the latter is not popular in related areas, it is a crucial teaching tool in education (Naik, 2015).

1.4 Research gap

Previous educational research concentrated on the application and effectiveness of gamification and digital game-based learning, especially in targeted primary students (Jong, 2015; Tüzün et al., 2009; Papastergiou, 2009). Only a few studies fill in part of the research gap by investigating non-digital games in educational settings (Dicheva, Dichev, Agre & Angelova, 2015). While researchers (Mayo, 2009) insist on the positive effect of gamified education compared to traditional teacher-oriented pedagogy, Kim, Song, Lockee & Burton (2018) declared uncertainties on the efficacy of gamification for learning and teaching, such as participants' ages, subject matter, and game design.

Meanwhile, there are missing puzzles on the relationship between various gaming and teaching in aspects of learning outcomes. There has been very little research focused on the linkage between the implementation of different scales of game elements and participants' learning outcomes in secondary geographical education. More comprehensive empirical research is required to complete the related study area, especially the most effective adaptation of game elements in teaching.

1.5 Research question

Based on the background, this paper mainly investigates the relationship between gaming elements and students' effective learning, and ultimately identifies an optimal level of gaming implementation in teaching geography. Research questions are designed according to learning outcomes categories under geographical education.

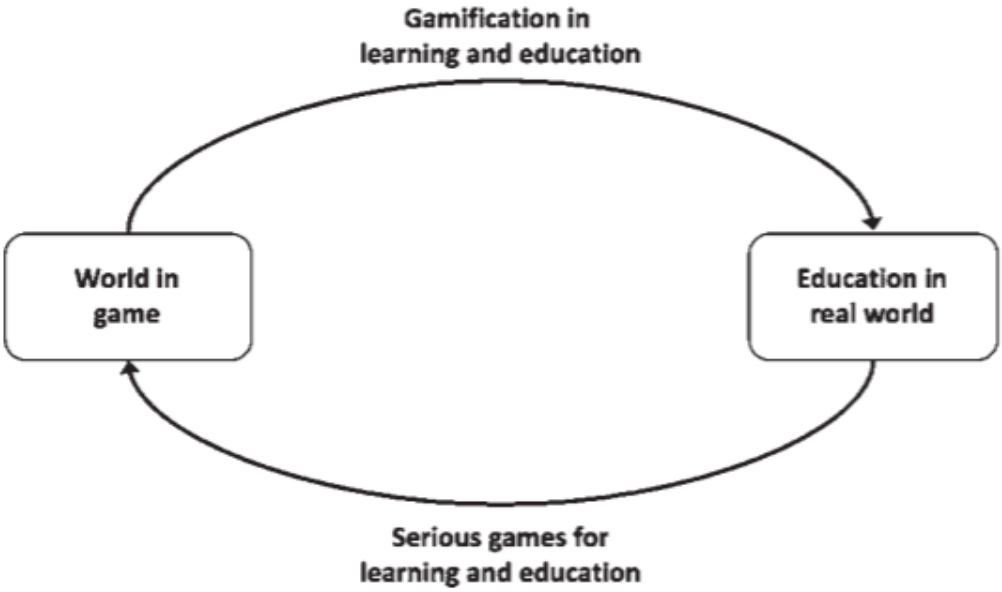
- What are the motivation differences between traditional learning, gamification, and game-based learning respectively?
- What are the knowledge-test differences between traditional learning, gamification, and game-based learning individually and comparatively?
- What is the best practice of game elements applied in geographical education?

2. Gamification and Geographical Education: Towards a Theoretical Framework

2.1 Theoretical bases of gamification

Games in education include gamification and serious games. Gamification refers to activities that only involve game mechanics, while serious games are additionally embedded with educational objectives and related to real-world problems. The latter are tools in game-based learning widely, where players learn while playing.

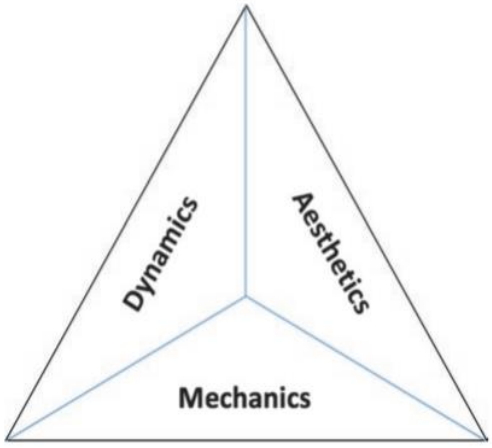
Figure 1. Relationship between serious game and gamification



Note. The image was created to clarify the meaning of gamification in learning and education.From Kim, Song, K., Lockee, B., & Burton, J. (n.d.). Gamification in Learning and Education. Springer International Publishing. https://doi.org/10.1007/978-3-319-47283-6 Copyright by Springer International Publishing

All games have distinct parts: rules, systems, and fun based on a foundation gamification design - MDA framework with three core elements: mechanics, dynamics, and aesthetics (Hunicke et al., 2004; Zichermann & Cunningham; 2011) (see Figure 2.). These elements create stimulators that could be associated with the learning process. Challenge, curiosity, and control are some illustrations (Kim et al., 2018).

Figure 2. MDA Framework



Note. The image was created to clarify the theoretical gamification framework. From Kim, Song, K., Lockee, B., & Burton, J. (n.d.). Gamification in Learning and Education. Springer International Publishing. https://doi.org/10.1007/978-3-319-47283-6 Copyright by Springer International Publishing

2.1.1 Mechanics

Mechanics is the fundamental component in providing rules for players' game experiences. Points and rewards are some illustrations (See Table 1). The combination of various elements demonstrates different game experiences. For example, the mix of points, leaderboard, and achievements creates a competition.

Table 1. Variations of mechanics in gamification model

Type	Mechanics
Player progression	Points (score) Achievement (badges, trophies, reward system or other forms) Leaderboard Levels (level up system)
Tasks	Missions (quests, optional assignment, mission selection, collect object, or others) Mini games (quiz, puzzle)
Game content	Role-playing Unique controllers Simulation Drag and drop Turn – based
Additional feature	Feedback Map Background story Characters GPS location Obstacles and enemies Tutorials (audio, video, animation) Social media platform (chat feature or forum) Items Increasing difficulty Tooltips & hints Augmented Reality Virtual Reality

Note. Reprinted from "Analysis of Gamification Models in Education Using MDA Framework", by Kusuma, Wigati, E. K., Utomo, Y., & Putera Suryapranata, L. K.,2018, Procedia Computer Science, 135, 385–392. https://doi.org/10.1016/j.procs.2018.08.187 Copyright by Procedia Computer Science

2.1.2 Dynamics

Dynamics refers to experiences formed under the run of mechanics based on the game's context, constraints, and choices (See Table 2). An experience framework with 20 categories was suggested by Korhonen, Montola, and Arrasvunori (2009), including role-play, and competition.

Table 2. Variations of dynamics in gamification model

Type	Dynamics Description
Receive badges, achievement, or other rewards	Students with the best score receive rewards such as badges, achievement or redeemable rewards to boost their motivation in learning activities
Role-playing	Players can choose characters to play in the scenario provided in game
Non-linear progression	All mission can be done separately so users could choose any mission they want to do There are tutorials in many forms and player can choose to take it or not In some mission that involves collecting objects, player could collect them in any order
Real exploration	Player must finish tasks by explore real location with the help of GPS
In-game exploration	Player will explore the virtual environment of the game itself
Puzzle solving	The puzzle in this game could be done using player's own methods
Difficulty adjustment	Challenges that adjusted automatically based on players' performance
Hints	The game will provide help to guide players during gameplay
Management – simulation	Player can build their own of city/zoo/other business place by using resources like money and make sure the business itself succeeded
Turn – based	During gameplay, both party will be given limited time and number of moves each turn
Adaptation system	System will adapt and change based on user data and actions, and the changes will affect gameplay directly or indirectly
Quiz system	Multiple choices with points for each correct answer. The points will be shown after each question answered

Note. Reprinted from "Analysis of Gamification Models in Education Using MDA Framework", by Kusuma, Wigati, E. K., Utomo, Y., & Putera Suryapranata, L. K.,2018, *Procedia Computer Science, 135,* 385–392. https://doi.org/10.1016/j.procs.2018.08.187 Copyright by Procedia Computer Science

2.1.3 Aesthetics

Aesthetics is gamers' feelings and emotions brought by game experiences. It is the product of mechanics and dynamics. According to The PLEX model created by Arrasvuori and other researchers (2011), fantasy, challenge, and fellowship are some illustrations (See Table 3.). All experiences are possible to bring the emotion of fun to players. Despite there is no clear definition of'fun', Lazzaro (2004) suggested four elements to create 'fun', that are (1)Novelty;

(2)Challenge; (3)Friendship; (4)Meaning. Csikszentmihalyi (1997) Theory of flow also emphasized the role of a challenging but performable game experience. It is essential for players to enter an optimum stage for learning and academic achievement, known as 'flow'. Under this mental status, players put full concentration on the activity and forget the surroundings, including time and space.

Table 3. The PLEX Framework in gamification model

Experience	Description
Captivation	Forgetting one's surroundings
Challenge	Testing abilities in a demanding task
Competition	Contest with oneself or an opponent
Completion	Finishing a major task, closure
Control	Dominating, commanding, regulating
Cruelty	Causing mental or physical pain
Discovery	Finding something new or unknown
Eroticism	A sexually arousing experience
Exploration	Investigating an object or situation
Expression	Manifesting oneself creatively
Fantasy	An imagined experience
Fellowship	Friendship, communality or intimacy
Humor	Fun, joy, amusement, jokes, gags
Nurture	Taking care of oneself or others
Relaxation	Relief from bodily or mental work
Sensation	Excitement by stimulating senses
Simulation	An imitation of everyday life
Submission	Being part of a larger structure
Subversion	Breaking social rules and norms
Suffering	Experience of loss, frustration, anger
Sympathy	Sharing emotional feelings
Thrill	Excitement derived from risk, danger

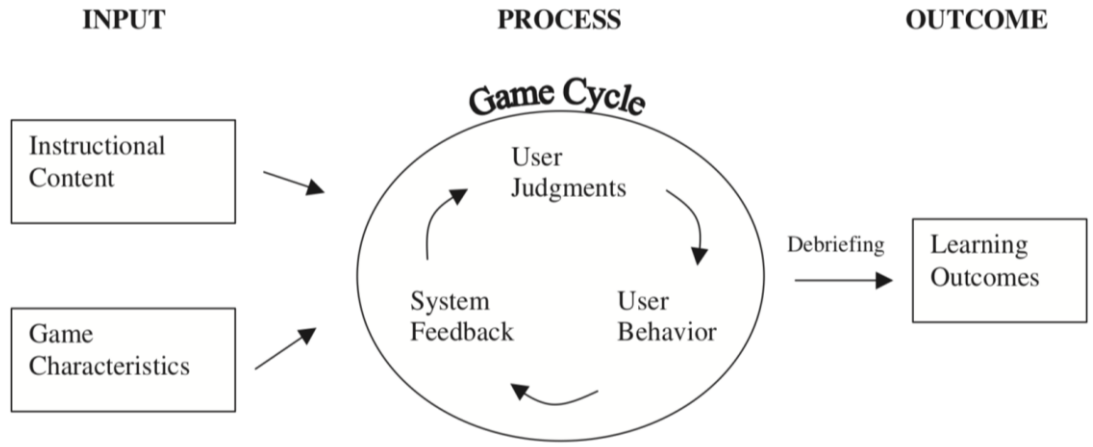
Note. Reprinted from "Applying the PLEX framework in designing for playfulness.", by Arrasvuori, Boberg, M., Holopainen, J., Korhonen, H., Lucero, A., & Montola, M.,2011, *Proceedings of the 2011 Conference on Designing Pleasurable Products and Interfaces, 1–8.* https://doi.org/10.1145/2347504.2347531. Copyright by Andrés Lucero

2.2 Theoretical bases of game-based learning

In most studies of instructional game structure, there is a tacit model of learning (see Table 4.). The base is that subject matters are injected into the game, presented in the form of game features and characters. These elements could activate a cycle of users' judgments, behaviours, and system feedback. In theory, an optimal design of a game could form iterative

judgment-behavior-feedback loops (Garris et al. 2002). It is a motivational process, resulting in sustained and self-motivated game experiences. The model emphasizes participants' trial-and-learn. Attempts trigger reactions like enjoyment and being interested, eventually leading to behavioural reinforcement and efforts intensification through system feedback on performance in the game context (Garris, Ahlers & Driskell, 2002). As this positive flow continues, participants' performance improves where related skills and knowledge required to cope with challenges can be mastered. Positive effects of game-based learning on science and engineering cognitive learning, including conceptual application and understanding of theoretical concepts, have been observed (Vlachopoulos & Makri, 2017; Chang et al., 2020).

Table 4. Input-Process-Outcome Game Model



Note. The image was created from a model of games and learning session to represent Input-Process-Outcome Game Model. From Garris, Rosemary, Ahlers, Robert, & Driskell, James E. (2002). Games, Motivation, and Learning: A Research and Practice Model. Simulation & Gaming, 33(4), 441–467. https://doi.org/10.1177/1046878102238607. Copyright by Naval Air Warfare Training Systems Center.

Concerning game nature, researchers have various views and qualifications in gamification. For example, some studies (Gibbons, 2013; Gredler, 1996; Holman, Aguilar, & Fishman, 2013) emphasized the element of goal complexity while others (Giannetto et al., 2013; O'Donovan et al., 2013; Li; Landers & Callan, 2011) argued on the importance of social engagement. However, five major theoretical basis contribute to the formation of gamification

in promoting effective learning (Kim et al., 2018). They are self-determination theory, situated learning theory, social learning theory, motivation theory, and achievement theory.

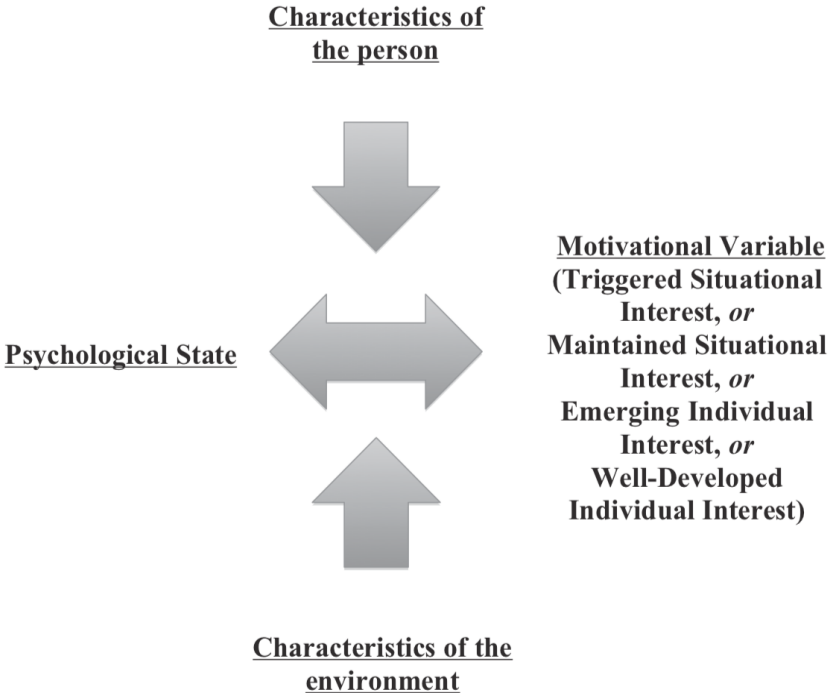
2.2.1 Self-determination theory

Self-determination is the foundation of motivation. Psychological needs, including autonomy, competence, and relatedness, encourage individuals to engage in activities. Feelings of controlling behaviour and consequences, which establish a sense of autonomy, can be satisfied with delegation to students in class decisions making. A sense of self-efficacy fosters competence while social activities meet relatedness. Several researchers suggest that intrinsic motivation can be triggered by a sense of competence (Deci & Ryan, 2013; İHSAN et al., 2015).

2.2.2 Situated learning theory

Interest is a psychological state with motivational variables that increase individual attention and encouragement in engaging a wide range of things, such as objects, tasks, and activities (Renninger & Hidi, 2017; Schiefele & Ulrich, 1991). The Four-phases model of interest development is divided into short-term and long-term. Triggering and maintaining situational interest is the initial step, whereas the emergence and development of individual interest is the ultimate goal (See Figure 3.). Once the short-term interest is formed, long-term individual interest can be developed with its remarkable effect on engagement.

Figure 3. The Interest Development



Note. The image was created from Define Interest to represent The Dual Meaning of Interest: A Psychological State and a Motivational Variable. From Renninger, K. A., & Hidi, S. (2016). The power of interest for motivation and engagement. Routledge. Copyright by Routledge.

In school settings, different aspects of classrooms could create interest. Presentation of learning materials and students' feelings are some illustrations (Linnenbrink-Garcia et al., 2010). In students' mindset, the assumption of learning as a single entity hides the full utilization of the actual world environment, resulting in difficulty in learning. However, it is suggested that interest and knowledge are learned under an imagined environment more readily than in a decontextualized form (Garris, Ahlers & Driskell, 2002).

Knowledge is a social construction outcome, implying people's understanding of learning in situated conditions. According to studies (McLeallan, 1996; Orgill, 2007) on situated learning theory, learning is a concept of understanding under an authentic context of the application and the social interactions during the progress. Learning is inseparable from environment and activity in related contexts (Collins, Brown, & Newman, 1989; Lave, 1988; Lave, 1991; Bell, Maeng & Binns, 2013; Kim, Song, Lockee & Burton, 2018). Knowledge construction only can be achieved by merging with the context of the physical environment in

learning. A virtual, situated background takes a crucial role in constructing an environment for effective learning (Cordova & Lepper, 1996; Kim et al.; 2018). Games expose students to situational interest and opportunities for prolonging learning. Situational interest refers to the reactions toward activities. Fantasies in games facilitate students' focalization and attention in the "world with no consequences" (Thomas and Macredie, 1994). They are necessary for supporting an individual's interest development.

2.2.3 Social learning theory

The theory of social learning has been applied in schools for decades. Implementation of gamified education greatly increases the weighting of interactivity between individuals, contributing to its efficacy in students' learning outcomes (Thornton & Cleveland, 1990). Social learning allows people to learn from each other in various ways: information transmission from observation, imitation, and deliberation, exchanges of views through arguments and persuasion (Bandura; 1977; Habermas, 1981; Kim et al.; 2018; Newig et al., 2010). In game time, students not only pay attention to peers' behaviors, evaluate and discuss their actions, but also duplicate those behaviors that are preserved as correct based on the consequences to achieve the game mission. Similar actions applied to instructions and demonstrations made by teachers as well. However, gaming brings students' different knowledge systems and world perceptions together, affecting subsequent learning outcomes (Wildemeersch 2007). Compared to teacher-orientated lessons, these social gaming experiences allow students to learn faster with high engagement (Wildemeersch et al., 1998, Benn 2000). Therefore, the learning efficiency can be increased by enhancing the chances of students' group learning.

2.2.4 Motivation theory

In general, motivation is the psychological process where students continuously engage in learning through establishing a connection with their surroundings (Akbaba, 2006; Geen,

1986; Yildirim, 2017). As a variable of interest, motivation is an essential qualification and reinforcement that provides energy in achieving a goal (i.e. sustaining continuous learning) (Hu, 2008; Girmus, 2012; Kaya, 2013). Effective learning fails without motivation and engagement.

2.2.4.1 Intrinsic motivation It refers to people interest, pleasure, and curiosity about things. Being approved by studies (Gros 2007; Habgood 2007; Hakulinen et al., 2013; Nah et al., 2014; Su & Cheng, 2015), the game itself has the motivational power to attract students' engagement, promoting them to be self-directed and self-motivated in achieving learning outcomes.

2.2.4.1 Extrinsic motivation It is formed by environmental and external factors, like rewards, punishment, pressure, etc. According to Csikszentmihalyi Flow Theory (1997), ideal conditions of a motivating learning environment can be created with eight components: (1) Challenges match skills; (2) Clear goal; (3) Concentration and focus; (4)Control; (5)Direct feedback; (6)Loss of self-consciousness; (7) Autotelic and; (8)Transformation of time. Interestingly, these elements are associated with the game design MDA framework. With clear goals, direct feedback, and the balance of challenge and autonomy, participants can be highly engaged in game experiences.

No research emphasized on any type of motivator in promoting persistent learning (Renninger & Hidi, 2017). It is hard to clarify the weight of contributions from intrinsic and extrinsic motivation separately as students can be motivated intrinsically and extrinsically at the same time (Garris, Ahlers & Driskell, 2002; Lepper, Corpus & Iyengar, 2005; Lepper, Greene & Nisbett, 1973; Scanlon, Anderson & Sweeney, 2016). Yet, in facets of academic learning and achievement, intrinsic motivation contributes more than extrinsic motivation (Deci & Ryan, 2000; Garris, Ahlers & Driskell, 2002; Taylor et al., 2014). It shares similar viewpoints with several studies on intrinsic learning. Intrinsic learning can be fostered by intrinsic

motivation factors such as curiosity, challenge, and fantasy included in gaming (Egenfeldt-Nielsen 2006; Garris et al. 2002; Malone, 1981; Prensky 2003).

2.2.5 Achievement theory

A specific and achievable goal can motivate individuals and determine achievements (Dweck & Leggett, 1988; Elliott & Dweck, 1988; Van Yperen, Blaga, & Postmes, 2014). There are two types: master goals with the desire for abilities acquisition and performance goals on higher achievements with peer comparison (Hamstra, Yperen, Wisse, & Sassenberg, 2014; Pekrun, Cusack, Murayama, Elliot, & Thomas, 2014). Mastery goals are relatively good for prolonging learning by fostering an individual's self-regulation, self-efficacy, and academic achievement (Linnenbrink, 2005; Robinson, Palmer, & Bub, 2016). Performance goals, by contrast, possibly enhance or discourage motivation for high achievement (Schunk & Mullen, 2012). In application, types of goals will be swapped according to changes of the individual psychological mindset as students' motivation and interest are coherently associated with achievement.

Gamified education contains clear missions and goals related to subject matters for players to strike for. It is highly recognised for its effectiveness in improving learning achievements (Domínguez et al., 2013; Li et al., 2012; Nah et al., 2014; Smith & Baker, 2011; Su & Cheng, 2015). High-order thinking skills, and cognitive-based learning outcomes, including declarative knowledge, procedural knowledge, and strategic knowledge are some examples. A significant statement was conducted by Randel et al. (1992) that the more specific the subject matter is, the greater beneficial effects are shown by gamified education.2.3 Theoretical bases of geographical education

2.3 Theoretical bases of geographical education

The ultimate goal of geographical education is to facilitate students in application and decision-making on various issues, such as socio-economic inequalities and natural disasters. The American National Geography standards defined essential skills for geography learners, including the ability to ask geographical questions, acquire geographical information, organize geographical information, analyse geographical Information, and respond to geographical questions (Ünlü & Yıldırım, 2017). The term 'Geoliteracy' is recently used to describe core skills in geographical education: the ability to use geographic knowledge and reasoning in decision-making (Anne, 2019; Robinson, Hardman & Matley, 2021). It covers the whole spectrum of geography from urban planning to climate change with three central aspects. They are interactions, interconnections, and implications. Learners firstly learn how our world works and connect and secondly make reasonable decisions for the Earth and human society through systematic analysis of findings based on priorities.

2.3.1 Game in geographical education

Instrumental games have existed since the Middle Ages (Von Hilgers, 2012). People viewed geography as a subject in the discussion of establishing a polite society. It prohibits the pop-up of board games in teaching geography based on specialized textbooks targeted for the upper and middle classes who aim to improve children's geographical education. Since then, board games have been used in geographical and planning education as well as for practical applications (Smith, 2010). Formats like Participology and Geogopoly based on role-play mode are widely applied in different topics in the geography curriculum.

The effectiveness of game-based learning in geography classrooms had been approved. Through interactive role-play, various real-world problems can be addressed in different ways. Not only geographic concepts but also strategies and skills used in the game, such as critical thinking, could be conveyed easily in a fun environment. Sardine and Fotaris (2020)

emphasized board game contributions to the development of geographic literacy, especially in the theme of space and place. Students' stereotype ‘tedious’ towards learning geography could be transformed into ‘memorable’ and ‘fun’. Her findings reconfirmed the findings of Virvou, Katsionis, and Manos (2005) that geography game environments attract low-performers attention, coping with the problem of boredom in particular topics. Meanwhile, some researchers agreed that geography games generate a range of perceptual, cognitive, and behavioural learning impacts by simulating the world beyond the classroom (Hamari et al., 2016; Yildirim, 2017; Tuzun et al. 2009).

3. Climate Change Education under geographical education

Climate change involves two cores: ‘Climate’ explains the natural sciences, while ‘change’, or educating for change, involves engaging the social sciences and humanities (McKeown & Hopkins, 2010). Thus, education on climate change focuses on learning knowledge, skills, values, and action toward complex issues in the face of uncertainties and rapid climate change (Hung, 2014; Stevenson, Nicholls, & Whitehouse, 2017). Learners are expected to be involved in this global issue from awareness to knowledge about causes and impacts, and ultimately, to participation in management. In the Hong Kong Geography curriculum, 84 hours are spent in junior forms while 195–220 hours are spent in senior forms under a detailed learning guideline set in the Geography Curriculum and Assessment Guide (Jackson & Pang, 2017) (See Figure 3.). However, not all countries view climate change as an independent topic and establish comprehensive guidelines. In Singapore, climate change education concentrated on taking action for the environment. In some countries like Greece, climate change education is not explicitly included in the curriculum, but rather in existing school subjects (Koulaidis & Christidou, 1999).

Figure 4. Teaching Kit of Climate Change Education

Note. The image was created from a teaching kit according to the module of 'Climates Change – Long-term fluctuation or irreversible trend?' in Geography Curriculum and Assessment Guide. From Jessie Lau (n.d.). Establishment of Geography E-learning Package about Climate Change. Copyright by Ho Koon Nature Educa>on cum Astronomical Centre. https://www.edb.gov.hk/attachment/tc/curriculum-development/kla/pshe/references-and-resources/geography/Geog_e-Learning_package_on_climate_change.pdf

3.1 Tradition approach I

Like other subject education, climate change education is under traditional Chinese mode, which means a teacher-centred and exam-oriented approach. Climate change education concentrates on students' cognitive level, expecting them to be awakened and interpret human linkages in the biotic community as a pedagogical and practical task in climate change education (Howard, 2013). However, marks in examinations only reflect students' memorization ability and are irrelevant to students and their present realities. Climate change knowledge should be taught in a more tangible way to raise the consciousness of students (Hung, 2014).

3.2 Tradition approach II

Climate change education cannot be confined to traditional structures but be drawn to a new hybrid environment. It is suggested that alternative practice-centred social learning approaches should be applied, such as competition and research (Hung, 2014; Lotz-Sisitka 2008). It allows learners to be empowered in climate change education beyond awareness of climate change facts. Schools in Australia used project-based pedagogies. Students' progress inquiry works with autonomy which enhances the relevance of their learning content. On the topic of international cooperation, group learning is evaluated with a higher rating in learning outcomes (Vinke-de, & Pahl-Wostl, 2016).

3.3 New approach

Among recent pedagogical developments, there is an increasing focus on social learning and situated learning in the context of climate change education (Kagawa & Selby, 2010). Game-based intervention which suits the above trend is preferred over other methods as it provides motivation, an enjoyable ludic experience, and social interaction (Fernández et al., 2021). Game-based climate change education is a nascent area that needs to be investigated in the learning of environmental and social sciences.

As discussed, the above parts show comprehensive keys to both gamification and game-based learning in reaching effective academic learning. Games address a wide range of learning goals from knowledge to affective and behavioural engagement, coping with the core problem of low engagement. This paper is going to focus on the following theories that may be associated with the research theme: climate change education under geography education:(1) Motivation Theory which claimed games as an intrinsic motivator in promoting self-engagement in learning; (2)Situated learning Theory where fantasies easily dragged

participants into situational interest; and(3)Interest Development Theory that demonstrates the process to prolonging individual learning interest.

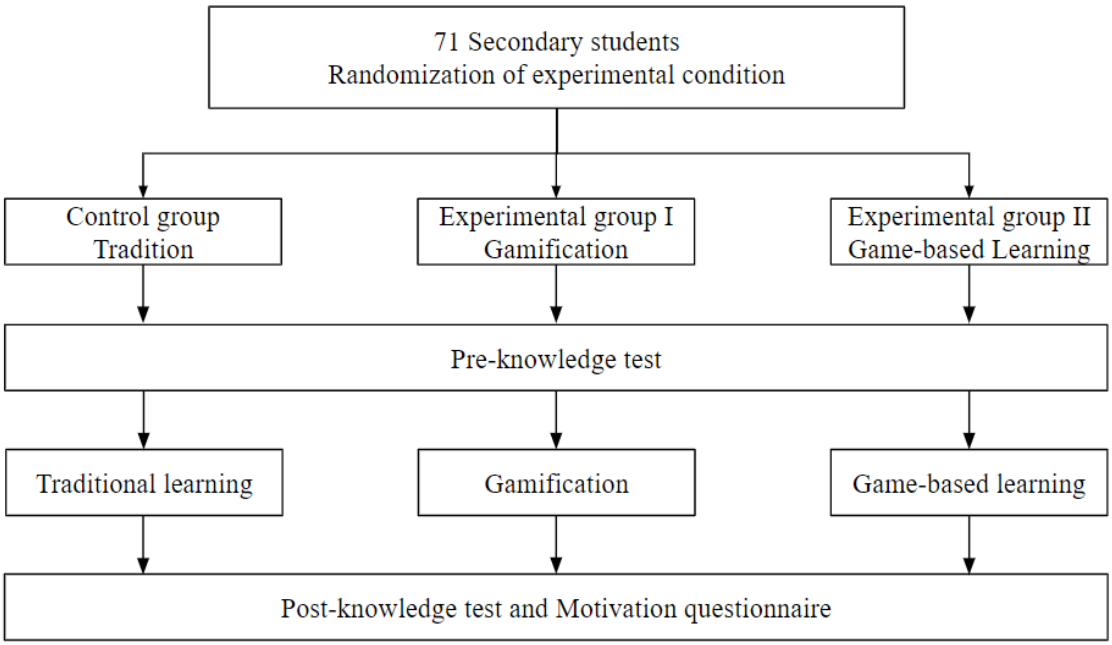
4. Methodology

This paper aims to compare the motivations and cognitive learning outcomes of students who learned climate change national cooperation in class with a variety of game elements. This chapter provides the research's detailed description, including research design, targeted population, hypothesis testing, data collection tools, and statics tools.

4.1 Research design

The design methodology used is quantitative and experimental research. The study was conducted in three different modes of geography lessons in November 2021.

Figure 5. Experimental design with two experimental groups and a control group



4.1.1 Theme

The theme is national cooperation on climate change with three cognitive learning outcomes. They are (1) To categorize countries in development levels; (2) To describe national community climate agreements; (3) To explain factors of countries withdrawn in climate agreements.

4.1.2 Lesson design

In the theme of climate change national cooperation, most of the knowledge is facts that require students to recognise and remember. To deal with boredom, gamified elements could be powerful in facilitating students' cognitive learning outcomes.

4.1.2.1 Gamified class Experiment group I is designed with two collaborative inter-group competition activities. Students in groups of four have to cooperate and finish matching tasks based on their understanding before learning new concepts. The following table lists the game design framework.

Table 5. Gamified class game design framework

	Mechanics	**Dynamics**	**Possible Aesthetics**
Player progression	Score Leaderboard Achievement with rewards	Matching with points for each correct answer. Group with best score receive rewards	Challenge Control Competition Fellowship
Task	Mini game: Quiz system		
Game content	Drag and drop		

Both competition and collaboration learning activities have strong motivation power. Still, competition only motivates high-achieving and ambitious learners but demotivates the relatively low-achieving ones. According to Elliot, Jury, and Murayama (2018), relatively low-achieving students lack confidence in demonstrations, resulting in low participation in competitions. Integrated with collaboration within groups, low-achieving students are more willing to demonstrate their skills as a unity of the team. Hence, collaborative, competitive

gamification could maximise its effectiveness by complementing each other (Ke & Grabowski 2007; Burguillo 2010; Murray, 2019).

4.1.2.2 Game-based class Experiment group II is designed with non-digital game-based learning activities. The game vision is to balance the use of limited resources between relieving climate change and the country's development. Players are expected to experience the negotiation on resources distribution for agreement implementation. Game cards are designed to stimulate students' learning engagement and boost their cognitive learning outcomes in a new learning environment (Cordova & Lepper, 1996; Kim et al.; 2018). Such a microworld-based role-playing game could achieve maximum effect in learning outcomes (Huang et al., 2014; Law & Chen, 2016; Wang et al., 2017).

Table 6. Game-based class design framework

	Mechanics	**Dynamics**	**Possible Aesthetics**
Player progression	Score Leaderboard within groups	Each player has a character to play and manage own resources	Simulation Challenge Control Fellowship Competition
Task	Mission		
Game content	Role-playing Management Simulation		

Students in groups of four have to play three rounds with a set of cards. Each student, acting as a representative of a country randomly (Developed countries and developing countries), has different levels of resources (Labour, Technology, and finances) referenced to reality. All members participate in a climate change national conference and choose whether to implement agreements or not. To alleviate global warming, certain levels of mark have to be

gained by agreement implementation. The agreement's effectiveness is associated with the number of required resources. Table 5 lists the game design framework.

4.1.3 Lesson flow

Three lesson plans designed with different pedagogies were activated in classes separately: traditional teaching mode acts as the control group while gamification and non-digital game-based learning modes are experimental group I and experimental group II respectively. Detailed lesson plans are attached in Appendix while a comparative table is shown as follows. The data were collected under a pre-and-post-test and a knowledge-based test.

Table 7. A comparative table of independent groups

<table>
<tr><th></th><th>Control group: Traditional Class</th><th>Experimental Group I: Gamified Class</th><th>Experimental Group II: Game-based Class</th></tr>
<tr><td rowspan="5">Session 1</td><td colspan="3">Complete knowledge-test</td></tr>
<tr><td colspan="3">Play a video about global warming</td></tr>
<tr><td>Classify countries according to the development level with PowerPoint</td><td rowspan="2">Competition I - Countries Classification</td><td>Game introduction with video</td></tr>
<tr><td rowspan="2">Board Game time</td></tr>
<tr><td colspan="2">National contracts explanation with PowerPoint</td></tr>
<tr><td rowspan="3">Session 2</td><td colspan="2">Explain actual national cooperation situation with PowerPoint</td><td>Board Game time</td></tr>
<tr><td>Illustrate the argument of countries on withdrawn decision with PowerPoint</td><td>Competition II - Countries Withdraw Arguments</td><td>Debriefing</td></tr>
<tr><td colspan="3">Complete knowledge-test and motivation test</td></tr>
</table>

4.2 Target population

The population of this study is secondary students from Buddhist Sum Heung Lam Memorial College, aged around 15 to 16 years old. The experimental and control groups are randomly distributed based on classes.

Table 8. Research sample population

Group	Teaching mode	Number of participants
Control group	Traditional rote-learning	27
Experimental group I	Gamification	24
Experiential group II	Game-based learning	20
Total		71

4.3 Definition of variables

Quantitative variables are used to compare participants' performance under different pedagogies and to ultimately determine the optimal use of game elements in geographical education.

4.3.1 Independent variables

Three teaching modes would be the independent variable. Participants' pre-and-post knowledge-test scores vary based on experiencing any one type of teaching mode respectively.

4.3.2 Dependent variables

Knowledge test scores and motivation test results of three groups are dependent variables in comparison of learning outcomes and motivations. All results will be standardized with a full mark of 100.

4.3.3 Control variables

Age, teaching time, and test-completing time are used as control variables. All participants are Secondary three students aged between 15 and 16, All three groups will experience two sessions of 30-minutes lessons in school for learning about climate change. Five minutes are given to all participants to complete each set of tests.

4.4 Data collection instrument

4.4.1 Knowledge test

Cognitive learning outcomes are measured through three parts of valid matching questions in response to three learning outcomes respectively.

4.4.2 ARCS Motivation test

This research measures participants' psychological learning outcomes based on the Attention, Relevance, Confidence, Satisfaction (ARCS) questionnaire which is an instructional model developed by John Keller. There are 18 items divided into four groups of factors with an additional factor (Personal growth and social skills) with 3 questions. The 5-point Likert scale is applied to reduce the Asian respondents' bias (Truonhg, Yap & Ineson, 2012). 1=strongly disagree, 2=disagree, 3=neutral, 4= agree, 5=strongly agree were used to present respondents' opinions on lessons with game elements added in lesson at different scales.

4.4.3 Ethical considerations

According to Bryman and Bell (2007), the research participants' full consent has to be obtained at the initial stage. The aim of this research needs to be clearly stated in the participants' content form before having data collection. Misleading information should be avoided. All participants have the right to withdraw from the research at any time. All collected data must be ensured in anonymity under an adequate level of confidentiality and privacy protection. However, data can be shared with participants under request.

4.5 Statistical tools and hypothesis testing

Two types of statistical tools are used in this study to compare the cognitive and motivational learning outcomes of various groups. One-way ANOVA is used to analyse both

the motivational and cognitive learning outcomes difference between three dependent variables while paired t-test is used to analyse the pre-and-post knowledge test changes of each dependent variable. It is proved that these tests are reliable in identifying slight deviations from the assumptions of normality and equal variance among populations (Zar, 1999).

4.5.1 Paired-sample t-test

To compare the mean of pre and post-knowledge tests in each group, a one-sided paired-sample t statistic is adopted. P-value of ≤ 0.05 is used in analysing the significance of the difference between sample means. The null hypothesis is written as:

H_0 : There is no difference in each group in terms of pre-and-post knowledge test mean

H_1: There is a significant difference in each group in terms of pre-and-post knowledge test mean

The hypothesis is that the cognitive learning outcomes level increases after all modes of teaching, where the more game elements added in the lesson, the higher cognitive level established by students based on the significant value. To be specific, experiment group II is predicted to have the highest scores while experimental group I comes next and the control group has the lowest scores.

4.5.2 One-way ANOVA

With three types of teaching modes, a one-way analysis of variance (ANOVA) is used. P-value of ≤ 0.05 is used in analysing the significance of the difference between sample means of motivation and cognitive learning outcomes towards geography learning.

4.5.2.1 Motivational learning outcomes The null hypothesis is written as:

H_0 : There is no difference between the controlled group and experimental groups in terms of ARCS motivation test mean

H_1: At least one experiment group is different from the control group in term of ARCS motivation test mean

The hypothesis is that the more game elements added to the lesson, the higher motivation students have. To be specific, experiment group II is predicted to have the highest motivational scores while experimental group I comes next and the control group has the lowest scores.

4.5.2.2 Cognitive learning outcomes The null hypothesis is written as:

H_0 : There is no difference between the controlled group and experimental groups in terms of post-knowledge test mean

H_1: At least one experiment group is different from the control group in term of post-knowledge test mean

The hypothesis is that the more game elements added to the lesson, the greater the post-knowledge test difference. To be specific, experiment group II is predicted to have the greater scores difference with the control group.

4.6 Codification

Codification of categorical variables is required in the statistical software. A code system table is shown as follows.

Table 9. Code system

Code	Dependent variables / Group
1	Control group - Traditional teaching
2	Experimental group I – Gamification
3	Experiential group II - Game-based learning

5. Result

This chapter presents the results of three groups in terms of motivational learning outcome and cognitive learning outcome respectively. The first part concentrates on the intre-group comparison on general motivation tests as well as detailed aspects. The second part contains both the pre-and-post knowledge test differences and the inter-group knowledge test comparison.

5.1 Motivational test

Tables 10. and 11. show the result of the hypothesised relationship between various groups and motivational learning outcomes. A one-way ANOVA revealed that there was a statistically significant difference in test scores between groups (F (2,68) = 4.952, p = 0.01). Results indicated that the average motivation score was significantly higher in experimental group II (M= 79.56, SD=13.54) than those in both experimental group I (M=72.65, SD=19.30) and control group (M=64.32, SD=16.15). The null hypothesis of no significant motivational learning outcomes difference between teaching modes is rejected.

Table 10. Descriptives of Variance of Motivation Test

					95% Confidence Interval for Mean			
	N	*Mean*	*Std. Deviation*	*Std. Error*	*Lower Bound*	*Upper Bound*	*Minimum*	*Maximum*
1	27	64.32	16.148	3.108	57.93	70.71	31	100
2	24	72.95	19.300	3.940	64.80	81.10	20	100
3	20	79.56	13.533	3.026	73.23	85.90	58	100
Total	71	71.53	17.554	2.083	67.38	75.69	20	100

Table 11. One-way Analysis of Variance of Motivation Test

Source	*Sum of Squares*	*df*	*Mean Square*	*F*	*Sig.*
Between Groups	2742.095	2	1371.048	4.952	.010
Within Groups	18827.271	68	276.872		
Total	21569.366	70			

Among four aspects of ARCS motivation test (see Table 12. -15.), Attention, Confidence and Satisfactory have a significant difference between three groups (p-value= 0.03; 0.06; 0.039) while the relevance aspect nearly met the significance level of 0.05 (p-value= 0.084). The additional aspect, personal growth, and social skills also have a statistical significance with a p-value of 0.02 (see Table 16.).

Table 12. One-way Analysis of Variance of Attention

Source	*Sum of Squares*	*df*	*Mean Square*	*F*	*Sig.*
Between Groups	4376.276	2	2188.138	6.211	.003
Within Groups	23957.058	68	352.310		
Total	28333.333	70			

Table 13. One-way Analysis of Variance of Relevance

Source	*Sum of Squares*	*df*	*Mean Square*	*F*	*Sig.*
Between Groups	1715.761	2	857.880	2.574	.084
Within Groups	22667.338	68	333.343		
Total	24383.099	70			

Table 14. One-way Analysis of Variance of Confidence

Source	*Sum of Squares*	*df*	*Mean Square*	*F*	*Sig.*
Between Groups	3556.129	2	1778.065	5.554	.006
Within Groups	21768.519	68	320.125		
Total	25324.648	70			

Table 15. One-way Analysis of Variance of Satisfaction

Source	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1994.868	2	997.434	3.405	.039
Within Groups	19920.625	68	292.950		
Total	21915.49z3	70			

Table 16. One-way Analysis of Variance of Personal Growth and Social Skills

Source	*Sum of Squares*	*df*	*Mean Square*	*F*	*Sig.*
Between Groups	2220.63	2	1110.315	4.165	.020
Within Groups	18128.67	68	266.598		
Total	20349.30	70			

Scheffé post hoc test revealed a statistically significant difference in the motivation mean of the control group and experimental group II with the significance value is 0.011, which is below 0.05 (See Table 17.). Meanwhile, There is no statistically significant difference between the marks of experimental group I and the control group (p=0.189) or between marks of experimental group I and experimental group II (p=0.427). Thus, we can conclude that effectiveness on motivational learning outcomes increased from traditional rote-learning, gamification, to game-based learning.

Table 17. Scheffe PostHoc Test of Variance of Motivation Test

		Mean			95% Confidence Interval	
(I) Group	(J) Group	Difference (I-J)	Std. Error	Sig.	Lower Bound	Upper Bound
1	2	-8.630	4.668	.189	-20.31	3.05
	3	-15.242*	4.909	.011	-27.53	-2.96
2	1	8.630	4.668	.189	-3.05	20.31
	3	-6.611	5.038	.427	-19.22	6.00
3	1	15.242*	4.909	.011	2.96	27.53
	2	6.611	5.038	.427	-6.00	19.22

In inter-group comparison, attention is the only item with significant differences found in all groups (See Table 18.). Moreover, significant differences are found between control group and experimental group II in the aspect satisfactory, confidence and personal growth, and social skills (See Table 20. - 22.).

Table 18. Scheffe Post Hoc Test of Variance of Attention

		Mean			95% Confidence Interval	
(I) Group	(J) Group	Difference (I-J)	Std. Error	Sig.	Lower Bound	Upper Bound
1	2	-13.642*	5.266	.041	-26.82	-.46
	3	-18.253*	5.538	.006	-32.11	-4.39
2	1	13.642*	5.266	.041	.46	26.82
	3	-4.611	5.683	.721	-18.83	9.61
3	1	18.253*	5.538	.006	4.39	32.11
	2	4.611	5.683	.721	-9.61	18.83

Table 19. Scheffe Post Hoc Test of Variance of Attention

Table 20. Scheffe Post Hoc Test of Variance of Relevance

		Mean			95% Confidence Interval	
(I) Group	(J) Group	Difference (I-J)	Std. Error	Sig.	Lower Bound	Upper Bound
1	2	-7.245	5.122	.373	-20.06	5.57
	3	-11.954	5.386	.093	-25.43	1.53
2	1	7.245	5.122	.373	-5.57	20.06
	3	-4.708	5.528	.697	-18.54	9.13
3	1	11.954	5.386	.093	-1.53	25.43
	2	4.708	5.528	.697	-9.13	18.54

Table 21. Scheffe Post Hoc Test of Variance of Confidence

		Mean			95% Confidence Interval	
(I) Group	(J) Group	Difference (I-J)	Std. Error	Sig.	Lower Bound	Upper Bound
1	2	-7.593	5.019	.325	-20.15	4.97
	3	-17.593*	5.279	.006	-30.80	-4.38
2	1	7.593	5.019	.325	-4.97	20.15
	3	-10.000	5.417	.190	-23.56	3.56
3	1	17.593*	5.279	.006	4.38	30.80
	2	10.000	5.417	.190	-3.56	23.56

Table 22. Scheffe PostHoc Test of Variance of Satisfaction

		Mean			95% Confidence Interval	
(I) Group	(J) Group	Difference (I-J)	Std. Error	Sig.	Lower Bound	Upper Bound
1	2	-6.042	4.802	.457	-18.06	5.98
	3	-13.167*	5.050	.039	-25.80	-.53
2	1	6.042	4.802	.457	-5.98	18.06
	3	-7.125	5.182	.394	-20.09	5.84
3	1	13.167*	5.050	.039	.53	25.80
	2	7.125	5.182	.394	-5.84	20.09

Table 23. Scheffe PostHoc Test of Variance of Personal Growth and Social Skills

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1	2	-5.389	4.581	.504	-16.85	6.07
	3	-13.889*	4.817	.020	-25.94	-1.83
2	1	5.389	4.581	.504	-6.07	16.85
	3	-8.500	4.943	.235	-20.87	3.87
3	1	13.889*	4.817	.020	1.83	25.94
	2	8.500	4.943	.235	-3.87	20.87

5.2 Knowledge test

A paired t-test was conducted on three groups to determine if various modes of teaching lead to mean differences in knowledge. Table 24. shows that there was a significant effect for experiment group II (t = 26 w/ df=19, p = 0.000) at a significance level of 0.05, with students gaining knowledge after board game activities (M= -20.56, SD=12.03). Other two samples also have statistically significant differences in the control group (t = -3.068 w/ df=26, p=0.005) and experimental group I (t = -2.839 w/ df=23, p=0.009). Students in the control group reported relatively greater improvement on the knowledge test (M= -14.64, SD=24.79) than students in experimental group I (M= -11.11, SD=19.18). As values of all groups are various, the null hypothesis of no significant difference between pre-and-post knowledge tests between teaching modes is rejected.

Table 24. Knowledge-test Result Statistics I

		Mean	N	Std. Deviation	Std. Error Mean
1	Pre 1	46.57	27	23.145	4.454
	Post 1	61.21	27	17.091	3.289
2	Pre 2	49.07	24	16.437	3.355
	Post 2	60.19	24	12.332	2.517
3	Pre 3	50.83	20	13.521	3.023
	Post 3	71.39	20	13.032	2.914

Table 25. Knowledge-test Result Statistics II

		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	Pre 1 - Post 1	-14.638	24.793	4.771	-24.446	-4.831	-3.068	26	.005
Pair 2	Pre 2 - Post 2	-11.111	19.175	3.914	-19.208	-3.014	-2.839	23	.009
Pair 3	Pre 3 - Post 3	-20.556	21.028	4.702	-30.397	-10.714	26	19	.000

Scheffé post hoc test showed the difference between variable groups in pre-and-post-knowledge respectively. The pre-knowledge test result revealed no significant difference between all groups (Table 26.). It implies that all participants have nearly the same understanding of climate change international cooperation.

Table 26. Scheffe Post Hoc Test of Variance of Pre-knowledge Test

		Mean			95% Confidence Interval	
(I) Group	(J) Group	Difference (I-J)	Std. Error	Sig.	Lower Bound	Upper Bound
1	2	-1.68	5.11	.948	-14.47	11.11
	3	-3.40	5.44	.823	-17.01	10.21
2	1	1.68	5.11	.948	-11.11	14.47
	3	-1.72	5.58	.953	-15.67	12.22
3	1	3.40	5.44	.823	-10.21	17.01
	2	1.72	5.58	.953	-12.22	15.67

Unexpectedly, Table 27 shows that there is a statistically significant difference in the post-knowledge test score between experimental group I and experimental group II with a significance value are 0.045, which is below 0.05. Meanwhile, there was no statistically significant difference between scores of the control and group experimental group I (p=0.97) or between marks of control group I and experimental group II (p=0.66). It reflected that there is no distinctive variety between traditional pedagogy and class with game elements. The null hypothesis of no significant difference on post-knowledge tests between teaching modes is rejected.

Table 27. Scheffe Post Hoc Test of Variance of Post-knowledge Test

		Mean			95% Confidence Interval	
(I) Group	(J) Group	Difference (I-J)	Std. Error	Sig.	Lower Bound	Upper Bound
1	2	1.02	4.07	.969	-9.17	11.21
	3	-10.18	4.28	.066	-20.90	.53
2	1	-1.020	4.07	.969	-11.21	9.17
	3	-11.20*	4.39	.045	-22.20	-.21
3	1	10.18	4.28	.066	-.53	20.90
	2	11.20*	4.39	.045	.21	22.20

6. Discussion

Hypothesis of this study has been proven partially rational. In climate change education, motivational and cognitive learning outcomes under game-based learning are the highest. In terms of motivation, the level of engagement increases with increasing game elements added. Game-based learning indeed maximises students' engagement in the theme of national cooperation learning. Nonetheless, there are unexpected findings in the facets of climate change knowledge acquisition. No significant knowledge gain difference was proved between tradition pedagogy and classes with game elements, except gamification and game-based learning. This chapter will analyse the influence of game elements contributing to the above findings before making a thesis statement of the game application in future geographical education.

6.1 Influence of game elements on motivational learning

This study reconfirmed the significant impact of theories mentioned in the literature review. Motivation is associated with game elements. Among variables of this study, game-based learning gained a relatively higher motivation level. With an extremely significant value of 0.003 between game-based class and traditional class in terms of attention differences, the power of the game in raising students' engagement was confirmed. This finding echo numerous researchers' Motivational Theory. The game itself indeed is an intrinsic motivator while game mechanics settings are extrinsic motivators for attracting engagement (Gros 2007; Habgood 2007; Hakulinen et al., 2013; Nah et al., 2014; Su & Cheng, 2015). When applying games in the interest development theory, the game is a useful tool to trigger situational interests, therefore; it creates an opportunity for participants' long-term individual interest development.

Surprisingly, this study proved the contributions of other theoretical bases in motivation maximisation. Findings showed a highly significant value of 0.06, 0.39, and 0.02 on confidence; satisfaction; personal growth and social skills aspects respectively. The remarkable effect of game-based learning on engagement is attributed to game dynamics (control, competition, and

fellowship). Involved dynamics connected learning to psychological principles, like Self-determination Theory and Social Learning Theory, and promoted fun and enjoyable learning experiences successfully. This paper echoed previous studies (Wildemeersch et al., 1998, Benn 2000; Vinke-de, & Pahl-Wostl, 2016) that students have higher engagement in social gaming experiences.

6.2 Influence of game elements on cognitive learning

This study showed that there is a significant improvement in facets of all groups pre-and-post knowledge tests with a significant value smaller or equal to 0.05. The mean post-knowledge score difference of game-based classes is the highest (M=20.56). The lesson theme of this experiment - climate change national cooperation is hard knowledge, which is perceived as indubitably uncontested facts. Students may easily lose focus in class. Under no instructions on memorizing the knowledge, students in the game-based class were still able to gain relatively high scores in the post-knowledge test. It is reasonable to give credit to unique elements of game-based design in getting students engaged to be active learners successfully.

The first element to success is the game nature of trial-and-learn. It is believed that this game-based class performed an optimal game with judgment-behaviour-feedback loops mentioned by Garris (2022). After several attempts, students reflected on their performance and deepened their understanding of national cooperation subconsciously.

The second element is stimulation. Students acted as country representatives to alleviate global warming in simulated national meetings. Role design stimulated students' curiosity to ask geographical questions. It demonstrated the function of situated learning theory identified by previous research, where the game constructed a natural, virtual environment for effective learning (Cordova & Lepper, 1996; Kim et al.; 2018). As hard knowledge is merged as part of the game, knowledge acquisition becomes easier for students. Thus, this study agrees with the power of gameplay elements in engaging students cognitively, including knowledge

acquisition, conceptual application, and understanding of theoretical concepts, especially under role-play, collaborative play, and competition (Vlachopoulos & Makri, 2017; Subhash and Cudney, 2018). Abstract and factual knowledge, such as reasons for withdrawing climate change national agreements, can be collaboratively constructed through the game in an attractive context. Students could grasp these concepts in a casual, easy way and get rid of learning by rote.

In the comparison of cognitive learning outcomes between teaching modes, there is no significant pattern between traditional pedagogy and two classes with game elements while a distinguishing difference was found between gamification and game-based learning. While knowledge scores of the game-based class are the highest(M=20.56), that of the gamified class (M=11.11) are even lower than that of the traditional class (M=14.64). It implies that there are variables determining the level of cognitive learning outcomes in classes with game elements. The findings here disagree with general statements that gamification stimulates academic learning (Vogel, Vogel et al., 2006). The fact is that there are uncertainties that should be taken into account in affecting the cognitive learning outcomes of gamified teaching, including participants perceived academic ability and interest in educational content both in the game and in the classroom (Meluso et al., 2012).

6.2.1 Possible factors affecting cognitive learning outcomes

As Kim, Song, Lockee & Burton (2018) mentioned, different factors, including game design, define the efficacy of gamification for learning. There is a possibility that game design in gamified class determined the learning experience and affected cognitive learning outcomes.

The major factor is differences in game mechanics. Gamified learning was conducted with a quiz system while game-based learning was conducted with Roleplay simulation. Although quiz format has been claimed as an instrumental tool for enhancing knowledge mastery (Ranieri et al., 2018), it is hypothetical that the quiz system had relatively low

motivation power due to its similarity to formal assessment (e.g., tests and examinations). Negative feelings and emotions may be triggered in gamified class, affecting students' level of engagement in cognitive learning.

Another reasonable factor is the failure of reaching the optimal stage mentioned in Flow of Theory. Dynamics differences could lead to a world of differences in aesthetics and subsequent learning. It is reconfirmed by this research findings, where motivation level in gamified class is relatively lower than in that of game-based class. Various levels of challenging but performable game experience determine whether students reach the flow of learning even with the presence of fun experiences.

6.3 Difficulties in implementing game-based learning

Game-based learning could maximize motivational and cognitive learning outcomes, yet there are limitations in the actual practice.

The critical problem is insufficient time. First of all, from a year plan design perspective, it is nearly impossible to adopt game-based learning as daily pedagogy with a tight teaching schedule set by the Hong Kong education system. As mentioned in chapter 3, the Hong Kong Geography curriculum suggested that only 84 hours should be spent on the theme of climate change. This experimental research has 2 lessons to teach climate change national cooperation, which belongs to 7.5.1 international cooperation. The fact is that this unit is only a minor part of Climate change education. Furthermore, from a view of lesson plan design, time management difficulties increase in student-orientated game-based learning. With an experimental nature, game-based lessons in this study had barely finished within a limited time without any assessments. Lots of time was spent on game instruction and setup. There was just a debriefing for active students to share their game experiences and reflections without formal knowledge transfer. It is important to note that there may be no time for assessments in measuring students'

learning outcomes in actual practice. In the long-term, problems of teaching failure will occur with numerous uncertainties on how much students learned.

Meanwhile, intense labour is required for high-qualified game-based learning. As most of the students are game beginners, close supervision and guidelines in each group are essential in running smooth game experiences. In the actual practice, teachers who hold the game alone may be overloaded on game setup, timekeeping, and guiding, let alone giving feedback to all students with various game experiences. The ideal solution is to assign teacher assistants in each group to facilitate students' game flow. But it is not feasible to implement in actual school settings with limited staff.

Also, there are limited qualified resources and skills for successful game-based learning design and its implementation. Although game-based learning has become more popular in recent years, most games are entertainment-oriented but irrelevant from the perspective of the learning aims (Clark et al., 2011; Wouters & Oostendorp, 2013). Modification is necessary for educational use. To suit the teaching syllabus, teachers have to tailor one. But another problem occurs, which is difficulties in selecting and integrating suitable games for teaching subject matter. Molin (2017) emphasized certain levels of gaming literacy acquisition in the integration of games into the curricula. This statement supports the fact that effective learning in gaming depends on a high-quality game design under the consideration of students' ability and challenges level. Both pedagogical and practical strategies are needed in promoting efficient and effective game-based learning (Jääskä & Aaltonen; 2022). Yet, as game-based learning is not mainstream in education, there is insufficient training and resources for teachers' application.

6.4 Implication: Mixed pedagogies in geography education

Although the application of non-digital games is not common, this study confirms its contributions in teaching factual geography concepts in climate change education (i.e., countries classification and climate change agreement contents) in a motivating atmosphere. Game-based learning is the ideal pedagogy for effective geography learning. Undoubtedly, with the nature of high motivation, games could get students engaged in the geography rationale between the Earth and human society. Game mechanics like role-play, simulation and map features allow students to learn geography in a more dynamic and easy-understanding way. There is unignorable power in the application of participology and geopoly in geography education. Based on literature review and the above findings, it is evident that game-based learning has a reaction to geographical education on the part of how the human world functions.

Unfortunately, due to the practical difficulties and constraints, game-based learning fails to be the dominant pedagogy in the present stage. Nonetheless, it is possible to embed some game qualities into daily lessons to replace drawbacks of traditional rote-learning.

6.4.1 Stimulated games as attention gain

At the beginning of a class, teachers should make good use of games as a short warm-up and learning target declaration in the first 5 to 10 minutes of class. Attention is crucial in determining students' engagement and learning outcomes. The higher participation a student has, the greater potential to have better academic performance. The first task for teachers is to stimulate student engagement. Game elements in an educational context not only catch students' attention but also act as a channel for students to be open in understanding subject knowledge with situated interest. Children are sensitive to the word ‘game’ based on the linked perception of enjoyment and fun, which are intrinsic motivators in a psychological perspective. The game brings chances for students to develop prolonged learning interests after the success of situational interest nourishment (Renninger & Hidi, 2017).

Based on the above findings, game design affects the effectiveness of learning. A warm-up should be carefully designed with consideration of students' traits, uniqueness of geography, as well as present learning objectives. It is suggested that the game design (mechanics and dynamics) should aim at a real-world simulation that brings a positive, playful aesthetic. Participology is recommended to satisfy students' psychological needs of self-determination, such as autonomy and competence, ultimately to maximise students' motivation through self-efficacy establishment. If learning objectives are spatial-related, map elements can be adopted in game tasks. Digital map applications like Google Map and Google Earth can be referenced. If learning objectives are related to human intervention and interconnections, simulation and role-play can be considered.

6.4.2 Tradition, teacher-orientation as knowledge transfer

There are two types of knowledge in forming cognitive outcomes in the human mind (Peng et al., 2021). They are tacit knowledge and explicit knowledge. One refers to subjective cognition and reflections of an individual's own experience while the latter refers to rational concepts that can be encoded and stored in various physical formats (Astorga-Vargas et al., 2017). Knowledge gained in the warm-up game is tacit only. A clear learning objective is important for students' organization of cognitive learning outcomes. Hence, a short transition statement should be made by the teacher in linking up to lesson learning objectives and focusing on explicit knowledge.

A great proportion of time should be spent on a detailed explanation of subject knowledge by the teacher. Complex rational concepts cannot be explained thoroughly by the educational game (O'Neil, Wainess, & Baker, 2005).

To compensate for this disadvantage of the game, teacher knowledge transfer is essential for a complete understanding. Moreover, as proved that there is no significance between knowledge score mean differences between game-based learning and traditional rote-learning, the latter is a more structured, clear, and effective way of knowledge transmission.

Thus, the traditional pedagogy should be retained as the major part of the lesson. The lesson has to shift from student-oriented to teacher-oriented. As an instructor, the teacher guides students on clarification of game-knowledge connection through direct fact-based learning under better time management.

6.4.3 Quiz-form gamification as reinforcement

Educational tools integrated with game elements could be used strategically as reinforcement at the end of the class. Game mechanics for competition, leaderboard and rewards can persist motivation for knowledge consolidation. Game tasks under quiz-form can be applied as the core purpose is to stimulate students' cognitive learning. Digital gamification for learning has become popular in recent years. Kahoot! Nearpod and Quizzes are some examples. Compared to formal, traditional assessments like homework, gamified assessment not only reinforces students' learning outcomes in an interesting and interactive way but also provides an instant report of students' performance.

6.5 Limitations of game element implication in geography education

Despite game-based learning strengths that can be extracted, it is not applicable in the whole spectrum of geography. Practices of real-world simulation and participology are more feasible in human geography. In climate change education, it is difficult to merge scientific concepts and natural sciences in classroom short games. Experiential learning like outdoor field trip is more suitable.

Apart from the suitability, the implementation barrier is similar to game-based learning, which is the limited acquisition of gaming literacy. Despite the proposed mixed pedagogy approach had been simplified and shortened, basic game knowledge is still essential. Teachers must spend additional time on game development and invest in the production of teaching materials. Lacking gaming expertise and related resources are difficulties in an effective gaming

implementation. More support from the Education Bureau is required as game specific skills are the foundation of designing effective learning through games.

Meanwhile, concepts of learning through games are new to both educators and the general public. Promotion of gamification may be required in raising the public acceptance towards gaming in classroom settings, otherwise, parents may complain and express their concerns of impropriety.

7. Conclusion and Limitations

Climate change has become a pressing environmental issue for humans. There have been increasing calls from the international community to stress the importance of climate change education under geographical curriculum in raising our next generation's awareness of climate change-related issues. Whilst environmental education has a rather long history, climate change education has been a recent phenomenon. This study has aimed to identify the best pedagogical practices that can promote climate change education. The study compares traditional rote-learning, gamification and game-based learning in terms of their effectiveness. It has been found from the study that while gamification and game-based learning has boosted students' engagement in the area of climate change, their effect on the knowledge level of the students fluctuated. For this reason, this study argues that a mixed pedagogy has the potential to be further applied in climate change education as well as human geographies. Hence, students can not only have joyful and meaningful learning experiences but appreciate the importance of climate change in the ever-changing world.

Nevertheless, the limitations of this study are the short experimental period and unstandardised sample sizes. Due to practical constraints, the data collocation time is restricted to two 30-minutes lessons per class. The target population of each class is fixed and pre-set. For future research, on a larger scale, the longer period experiment could be carried out on diverse populations such as gender and school brandings. Apart from the research collection settings, further study shall shed some light on the relationship between game design and cognitive learning outcomes along with other possible factors.

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9. Appendix

9.1 Control group

9.1.1 Lesson plan

Class Level ：S.3A

Date of lesson ：11/11/2021

Duration ： 30 minutes

Name of unit/ theme : Global Warming

Map reading skills Issue/ Problem/ Topic : What has been done by the international community?

Teaching Objectives/ Learning Outcomes（Knowledge / Skills / Attitudes）：

At the end of the lesson, students should be able to : Knowledge: To identify the national country in terms of development level To explain the national contracts in coping climate change

To illustrate controversial arguments of countries withdrawn

Teaching resources / Tools / Equipment：

PowerPoint, Notes

Blackboard/ Whiteboard Layout：

N/A

Students' Previous Knowledge：

N/A

Potential Learning Difficulties：

Students have low motivation for learning geography. Various learning activities are needed.

Students have slow handwriting, thus; more time is needed to meet their needs.

Time (Min)	Learning outcomes / Teaching Points / Content	Teaching Activities	Students' Tasks	Teaching Resources / Assessment / Remarks
5	Introduction on today's theme: Global warming	Distribute questionnaires to Ss Show a video about global warming and its effects *：We always hear about global warming but what is it actually?* *This video briefly explains it.* Raise Ss attention on the national solutions in coping with global warming *: Global warming is a pressing issue and the national community makes some conferences for adaptation. Can you give some examples?*	- Make notes *(Expected response)* *: Paris Agreement*	PowerPoint 1-2 https://www.youtube.com/watch?v=WDIQbZ4bgBg

		(If no responses from Ss, give guideline) *: What did the previous American President Donald Trump did in regard to environment policy?* *: Yes. All countries have their autonomy and decision-making in dealing with climate issues, including the national cooperation conference. Today, we are going to a group competition while learning. Please pay attention.*	*: Deprioritize climate action.*	
10	To identify the national country in terms of development level	- Briefly explain the definition of developed countries and developing countries *: There are some standards differentiating the countries. They are economic level, living standards and technology levels. Now, based on you and your groupmates understanding, try to do the matching.*	- Make notes *(Expected responses)*	PowerPoint 3 Textbook P.4

		- Ask Ss to spend 5 minutes think of examples in developed countries and developing countries based on their own understanding. - Show the correct answer - Explain why China belongs to developing countries	- *USA: More-developed countries; China: Less-developed countries* *-Make notes*	
10	To explain the national contracts in coping climate change	Show a timeline with national contract listed *: In history, the national community has been working on national contracts to alleviate climate change…*	- Make notes	PowerPoint 4-6

		Show a line graph about the trend of increasing global temperature for explaining the Paris Agreement content		
5	Consolidation and summary	-Summarize the present national cooperation situation - Raise a question about why some countries quit the contract based on countries development level : *The national cooperation did have conflicts. Based on your game experiences, try to think of the reason for quitting the contracts. Next lesson, we will continue on the game and have a deep look on the present situation.*		PowerPoint 10

Class Level ：S.3A

Date of lesson ：15/11/2021

Duration ： 30 minutes

Name of unit/ theme: Global Warming

Map reading skills Issue/ Problem/ Topic: What has been done by the international community?

Teaching Objectives/ Learning Outcomes（Knowledge / Skills / Attitudes）：

At the end of the lesson, students should be able to:

Knowledge:

To identify the national country in terms of development level

To explain the national contracts in coping climate change

To illustrate controversial arguments of countries withdrawn

Teaching resources / Tools / Equipment：

PowerPoint, Notes

Blackboard/ Whiteboard Layout：

N/A

Students' Previous Knowledge：

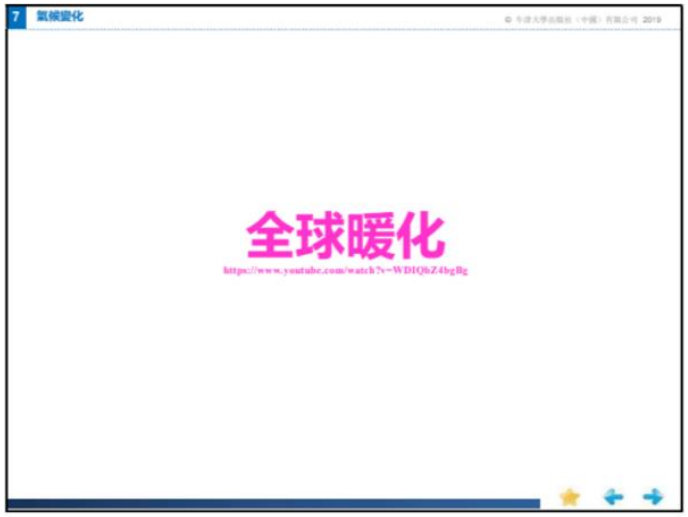
To identify the national country in terms of development level To explain the national contracts in coping climate change

Potential Learning Difficulties：

Students have low motivation for learning geography. Various learning activities are needed. Students have slow handwriting, thus; more time is needed to meet their needs.

Time(Min)	Learning outcomes / Teaching Points / Content	Teaching Activities	Students' Tasks	Teaching Resources / Assessment / Remarks
5	Recall memories	-Show the countries classification according to their development level		PowerPoint 3-6
10	To illustrate controversial arguments of countries, withdraw	- Emphasis on the actual national cooperation situation : The fact is that not all countries are willing to operate on the issue of climate change. Countries like the USA had quit. Can you estimate the reasons?	- Make notes *(Expected responses)* *- Poor; unfair*	PowerPoint 7-8 Textbook P.4
10	To illustrate controversial arguments of countries withdraw	- Briefly explain the properties of developed countries and developing countries	- Make notes	PowerPoint 9-11
5	Consolidation and summary	-Summarize the present national cooperation situation -Distribute questionnaires to Ss		PowerPoint 16

9.1.2 Teaching materials



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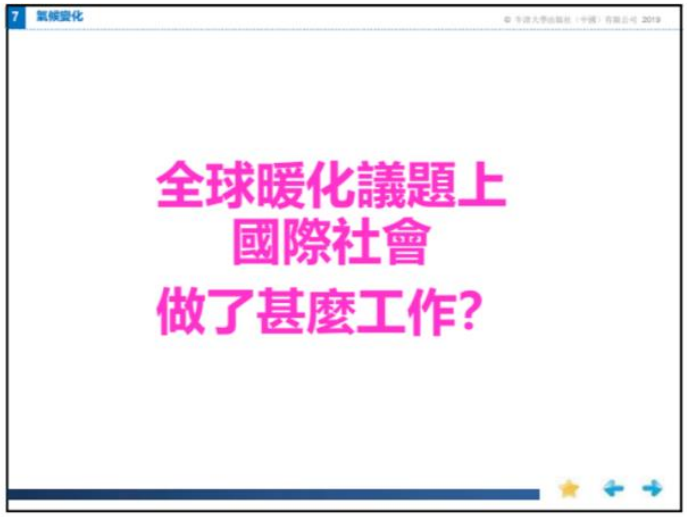

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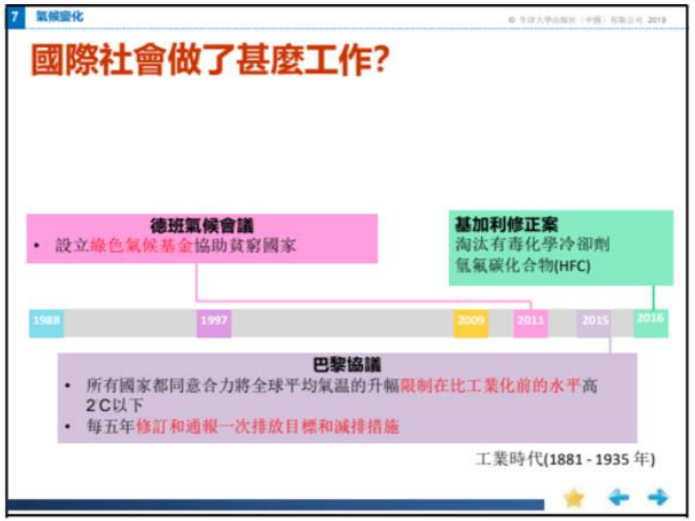

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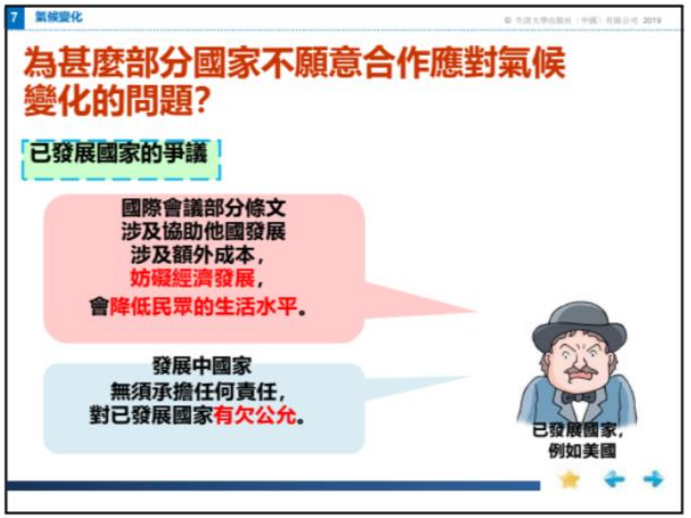

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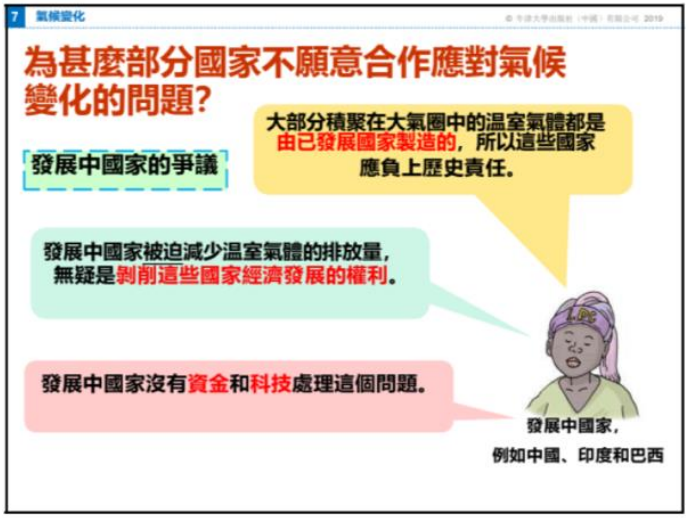


9.2 Experimental group I

9.2.1 Lesson plan

Class Level ：S.3B

Date of lesson ：11/11/2021

Duration ： 30 minutes

Name of unit/ theme: Global Warming

Map reading skills Issue/ Problem/ Topic: What has been done by the international community?

Teaching Objectives/ Learning Outcomes（Knowledge / Skills / Attitudes）：

At the end of the lesson, students should be able to :

Knowledge:

To identify the national country in terms of development level

To explain the national contracts in coping climate change

To illustrate controversial arguments of countries withdrawn

Teaching resources / Tools / Equipment：

PowerPoint, Notes

Blackboard/ Whiteboard Layout：

N/A

Students' Previous Knowledge：

N/A

Potential Learning Difficulties：

Students have low motivation for learning geography. Various learning activities are needed. Students have slow handwriting, thus; more time is needed to meet their needs.

Time (Min)	Learning outcomes / Teaching Points / Content	Teaching Activities	Students' Tasks	Teaching Resources / Assessment / Remarks
5	Introduction on today's theme: Global warming	Distribute questionnaires to Ss Show a video about global warming and its effects *：We always hear about global warming but what is it acutally?* *This video briefly explains it.* Raise Ss attention on the national solutions in coping with global warming	- Make notes	PowerPoint 1-2 https://www.youtube.com/watch?v=WDIQbZ4bgBg

		: Global warming is a pressing issue, and the national community makes some conferences for adaptation. Can you give some examples? *(If no responses from Ss, give guideline)* *: What did the previous American President Donald Trump do in regard to environment policy?* *: Yes. All countries have their autonomy and decision-making in dealing with climate issues, including the national cooperation conference. Today, we are going to a group competition while learning. Please pay attention.*	*(Expected response)* *: Paris Agreement* *: Deprioritize climate action.*	
15	To identify the national country in terms of	<u>Activity: Group Competition</u> Briefly explain the definition of developed countries and developing countries	- Make notes	PowerPoint 3-4 Textbook P.4

	development level	*: There are some standards differentiating the countries. They are economic level, living standards and technology levels. Now, based on you and your groupmates understanding, try to do the matching.* - Distribute group materials - Ask Ss to classify the given countries into developed countries and developing countries based on their own understanding. - Collect all group works - Show the correct answer - Ask and explain why China belongs to developing countries	- Discuss with groupmates about the country's development levels - Make notes	

5	To explain the national contracts in coping climate change	- Show a timeline with national contract listed *: In history, the national community has been working on national contracts to alleviate climate change…* -Show a line graph about the trend of increasing global temperature for explaining the Paris Agreement content	- Make notes	PowerPoint 7-10
5	Consolidation and summary	-Summarize the present national cooperation situation -Raise a question about why some countries quit the contract based on countries development level : *In reality, the national cooperation did have conflicts. Based on your game experiences, Try to think of the reason for quitting the contracts. Next lesson, we will continue on the game and have a deep look on the present situation.*		PowerPoint 10

Class Level ：S.3B

Date of lesson ：15/11/2021

Duration ： 30 minutes

Name of unit/ theme: Global Warming

Map reading skills Issue/ Problem/ Topic : What has been done by the international community?

Teaching Objectives/ Learning Outcomes（Knowledge / Skills / Attitudes）：

At the end of the lesson, students should be able to :

Knowledge:

To identify the national country in terms of development level

To explain the national contracts in coping climate change

To illustrate controversial arguments of countries withdrawn

Teaching resources / Tools / Equipment：

PowerPoint, Notes

Blackboard/ Whiteboard Layout：

N/A

Students' Previous Knowledge：

To identify the national country in terms of development level To explain the national contracts in coping climate change

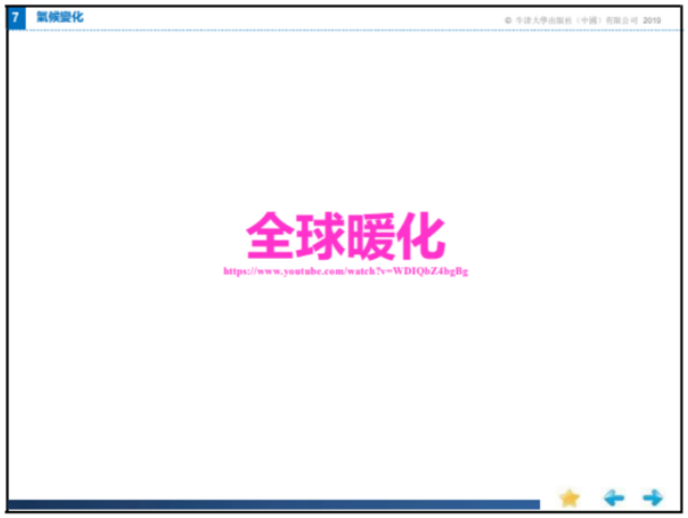
Potential Learning Difficulties：

Students have low motivation for learning geography. Various learning activities are needed. Students have slow hand-writing, thus; more time is needed to meet their needs.

Time(Min)	Learning outcomes / Teaching Points / Content	Teaching Activities	Students' Tasks	Teaching Resources / Assessment / Remarks
5	Recall memories	-Show the countries classification according to their development level -Distribute group works to Ss		PowerPoint 4-7
5	To illustrate controversial arguments of countries withdraw	- Emphasis on the actual national cooperation situation : The fact is that not all countries are willing to operate on the issue of climate change.	- Make notes	PowerPoint 9-10 Textbook P.4
15	To illustrate controversial arguments of countries withdraw	<u>Activity : Group Competition II</u> Briefly explain the properties of developed countries and developing countries	- Discuss with groupmates	PowerPoint 12

		- Ask Ss to rearrange the given statement into developed countries and developing countries based on their own understanding. -Collect Ss' group work - Show the correct answer	- Make notes	PowerPoint 13-15
5	Consolidation and summary	-Summarize the present national cooperation situation -Distribute questionnaires to Ss		PowerPoint 16

9.2.2 Teaching materials



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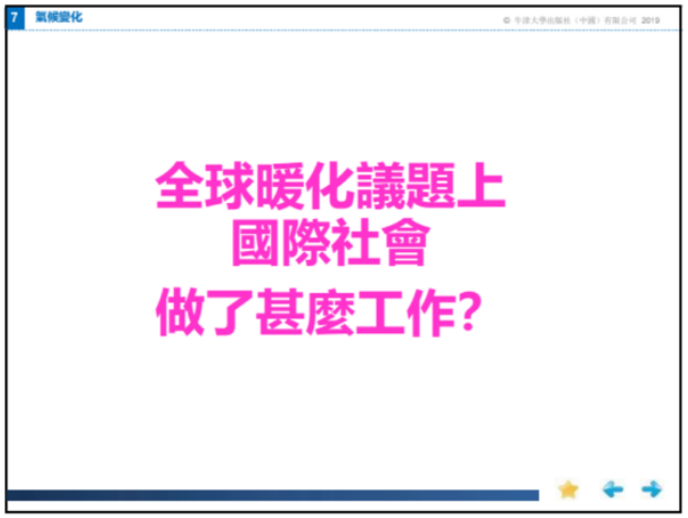

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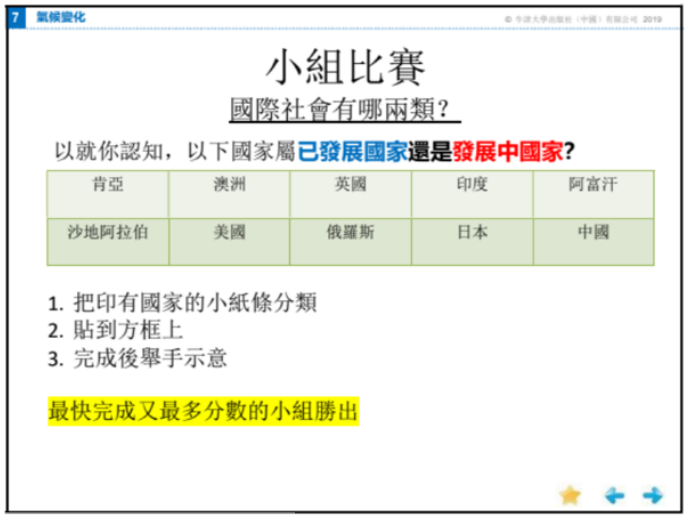

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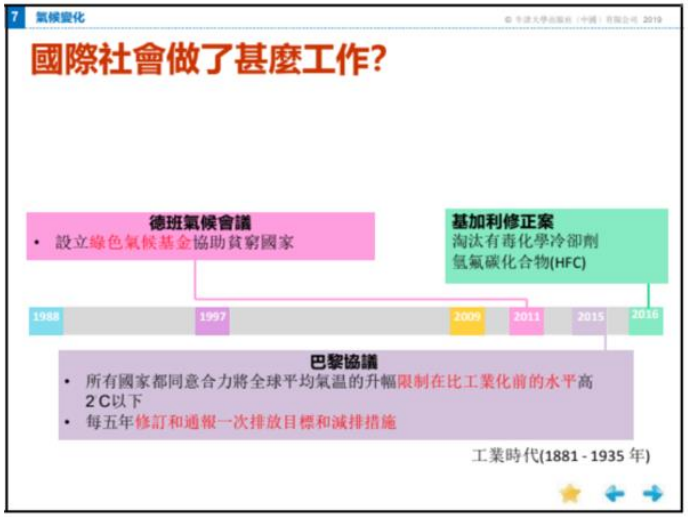
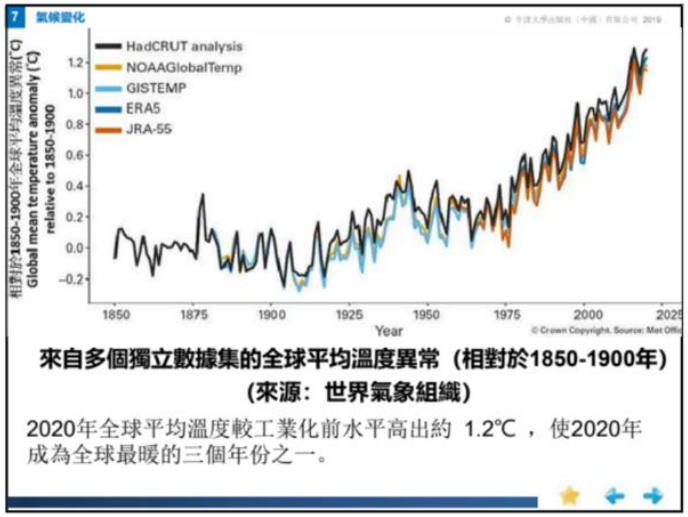




來自多個獨立數據集的全球平均溫度異常（相對於1850-1900年）（來源：世界氣象組織）

2020年全球平均溫度較工業化前水平高出約 1.2℃ ，使2020年成為全球最暖的三個年份之一。

7 氣候變化

國際社會做了甚麼工作?

- 減少國內的溫室氣體排放
- 已訂立較明確和具體的目標
- 已發展國家提供科技和財政資源，協助發展中國家減排，以及應對氣候變化的問題

9

7 氣候變化

國際社會做了甚麼工作?

- 但是，不是所有國家都願意合作減排，例如美國。

例如，美國、澳洲和加拿大分別於2001年、2002 年和2011 年退出京都議定書。

2017 年，美國政府宣佈退出巴黎協議。

10

7 氣候變化

小組比賽 2

在氣候協議中，國家為什麼不願意合作？

已發展國家	例如：
具有較高 → 生活質素 →發達經濟 →先進技術基礎設施	美國　俄羅斯 日本　英國　澳洲

發展中國家	例如：
具有較低 → 生活質素 →發達經濟 →先進技術基礎設施	中國 印度 肯亞 阿富汗 沙地阿拉伯

7 氣候變化

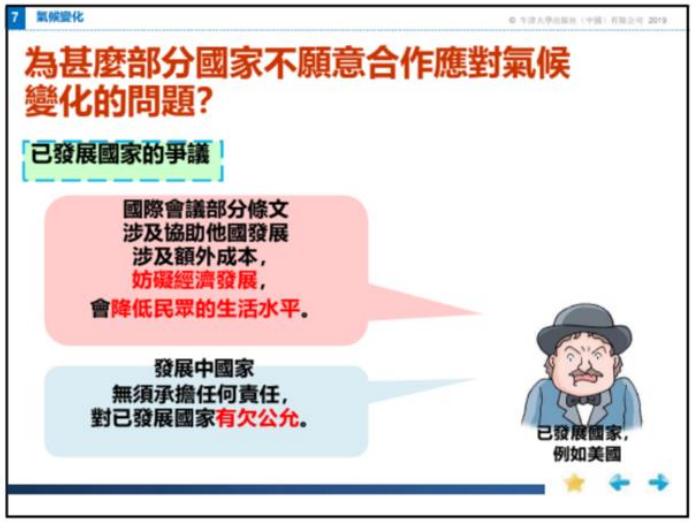
已發展國家

比較早發展
具有較高
→ 生活質素
→發達經濟 =（較富裕）
→先進技術基礎設施 =（科技較發達）

發展中國家

比較遲發展
具有較低
→ 生活質素
→發達經濟 =（較貧窮）
→先進技術基礎設施 =（科技較落後）

13



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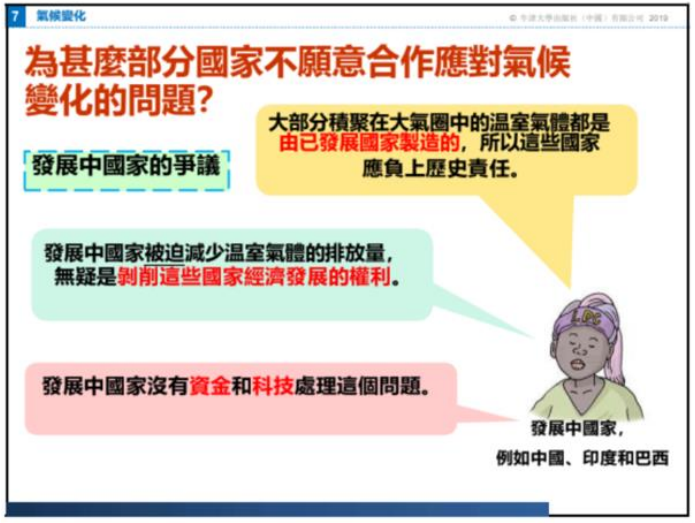

9.3 Experimental group II

9.3.1 Lesson plan

Class Level ：S.3C

Date of lesson ：11/11/2021

Duration ： 30 minutes

Name of unit/ theme: Global Warming

Map reading skills Issue/ Problem/ Topic : What has been done by the international community?

Teaching Objectives/ Learning Outcomes（Knowledge / Skills / Attitudes）：

At the end of the lesson, students should be able to: Knowledge: To identify the national country in terms of development level To explain the national contracts in coping climate change To illustrate controversial arguments of countries withdrawn

Teaching resources / Tools / Equipment：

PowerPoint, Card games, Game instruction video

Blackboard/ Whiteboard Layout：

N/A

Students' Previous Knowledge：

N/A

Potential Learning Difficulties：

Students have low motivation for learning geography. Various learning activities are needed.

Time (Min)	Learning outcomes / Teaching Points / Content	Teaching Activities	Students' Tasks	Teaching Resources / Assessment / Remarks
5	Introduction on today's theme: Global warming	Distribute questionnaires to Ss Show a video about global warming and its effects *：We always hear about global warming but what is it actually? This video briefly explains it.* Raise Ss attention on the national solutions in coping with global warming	- Make notes *(Expected response)* *: Paris Agreement*	PowerPoint 1 https://www.youtube.com/watch?v=WDIQbZ4bgBg

		: Global warming is a pressing issue, and the national community makes some conferences for adaptation. Can you give some examples? *(If no responses from Ss, give guideline)* *: What did the previous American President Donald Trump do in regard to environment policy?* *: Yes. All countries have their autonomy and decision-making in dealing with climate issues, including the national cooperation conference. Today, we are going to play a game. The fate of the Earth and a country's development depends on each of you. Before we start the game, let's take a look at the game instructions and rules.*	*: Deprioritize climate action.*	
5	Introducing the game rules	Introduce the game mode and Ss targets Display cards in PowerPoint Explain the meanings of each set of cards Play a video about the game flow		PowerPoint 2 PowerPoint 4-7

15	To identify the national country in terms of development level To explain the national contracts in coping climate change	<u>Activity: Group Competition</u> -Show the game flow and timer in the projector Distribute card game in each group - Set time limit for playing the card game - Assist groups that need help	- Play cards	PowerPoint 8
5	Consolidation and summary	-Debriefing with Ss on the playing experience *: How many resource cards do you have at the end of the game?* *: If you have no resource cards, what makes you contribute all your cards?*	*(Expected response)* *: 1 /2 /3 /4 /5*	

		: If you have many resource cards left, what encourages you to keep them? *: Is there any conflict between your group's cooperation, such as negotiating the contract to be implemented or who should contribute more resources cards?* - Raise a question about why some countries quit the contract *: In reality, the national cooperation did have conflicts. Based on your game experiences, Try to think of the reason for quitting the contracts. Next lesson, we will continue on the game and have a deep look on the present situation.*	*: Aimed at implementing the contract to meet target* *: Focus on my own country development in purpose to be individual winner* *: Some members reject to join the contract, rising the difficulty of contract implementation* *:Selfish?*	

Class Level ：S.3C

Date of lesson ：16/11/2021

Duration ： 30 minutes

Name of unit/ theme: Global Warming

Map reading skills Issue/ Problem/ Topic: What has been done by the international community?

Teaching Objectives/ Learning Outcomes（Knowledge / Skills / Attitudes）：

At the end of the lesson, students should be able to :

Knowledge:

To identify the national country in terms of development level

To explain the national contracts in coping climate change

To illustrate controversial arguments of countries, withdraw

Teaching resources / Tools / Equipment：

PowerPoint, Card games, Game instruction video

Blackboard/ Whiteboard Layout：

N/A

Students' Previous Knowledge：

N/A

Potential Learning Difficulties：

Students have low motivation for learning geography. Various learning activities are needed.

Time(Min)	Learning outcomes / Teaching Points / Content	Teaching Activities	Students' Tasks	Teaching Resources / Assessment / Remarks

3	Recall memories	Show a video about the game instruction : As a quick recall, let's have a look at the game instruction video. Briefly explain the cards in Powerpoint	-Watch video	PowerPoint 1-7
15		<u>Activity : Group Competition</u> Distribute card game in each group - Set time limit for playing the card game -Assist groups that need help	- Play cards	PowerPoint 8
7	To explain the national contracts in coping climate change	- Ask Ss about their playing experiences - Explain the concepts included in the card game *: As mentioned in the previous lesson, a similar situation is occurring in reality. All contracts in the game are real. They are…*	-Make notes	Powerpoint 10

	To identify the national country in terms of development level To illustrate controversial arguments of countries withdraw	-Explain the country distribution referring to the game *: What does the blue team and red team mean?* *:What are the main differences between them?* *: Absolutely. Apart from the economic level, there are more standards to differentiate them. They are living standards, technology levels.* - Describe the reasons of countries rejecting the participation of national contracts	*(expected responses)* *: More-developed countries ; Less-developed countries* *: More-developed countries are richer*	Powerpoint 11-16
5	Consolidation and summary	-Summarize the present national cooperation situation -Distribute questionnaires to Ss		

9.3.2 Teaching materials

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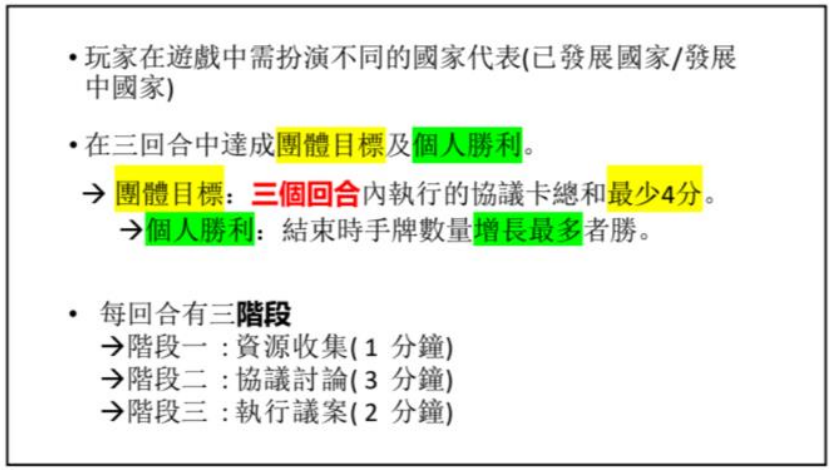

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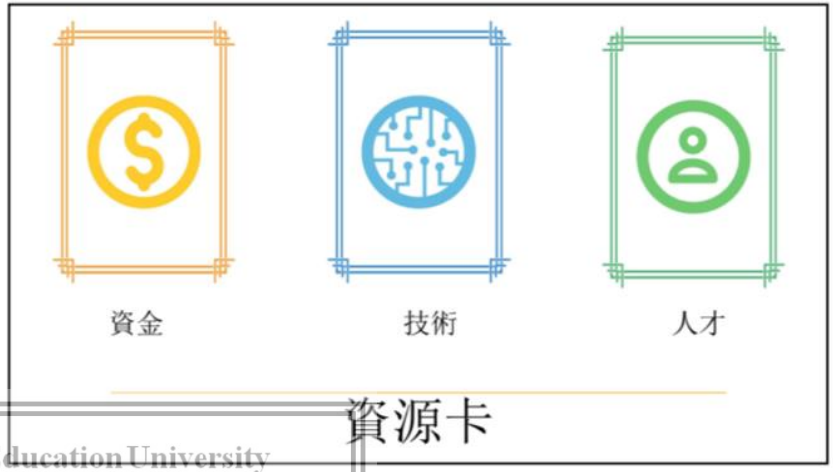

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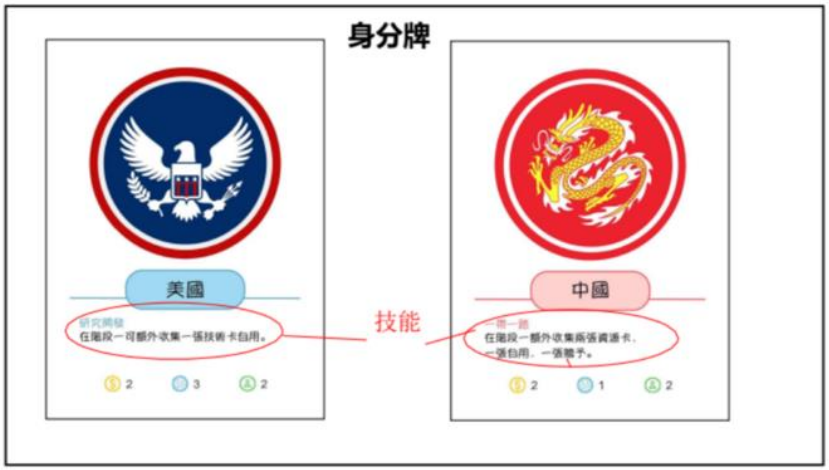

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7

每回合有三**階段**

→階段一：資源收集(1 分鐘)

→階段二：協議討論(3 分鐘)

→階段三：執行議案(2 分鐘)

回合完結

8

「氣候峰會」
坐在國際會議的圓桌前
地球和國家的命運
就掌握在你手上

你
會如何取捨？

9

國際社會做了甚麼工作?

蒙特婁議定書
淘汰化學物質氯氟烴（CFC）

基加利修正案
淘汰有毒化學冷卻劑氫氟碳化合物(HFC)

德班氣候會議
設立綠色氣候基金
協助貧窮國家

京都議定書
- 第一份訂定減排目標的國際協議
- 設立「配額買賣制度」

巴黎協議
所有國家都同意合力將全球平均氣溫的升幅限制在比工業化前的水平高2 C以下

10

國際社會做了甚麼工作?

- 減少國內的溫室氣體排放
- 訂立較明確和具體的目標
- 已發展國家提供科技和財政資源，協助發展中國家減排，以及應對氣候變化的問題

所有國家代表都願意合作嗎?

11

現實中，不是所有國家都願意合作減排。

例如，美國、澳洲和加拿大分別於2001年、2002 年和2011 年退出京都議定書。

2017 年，美國政府宣佈退出巴黎協議。

背後的原因是甚麼?

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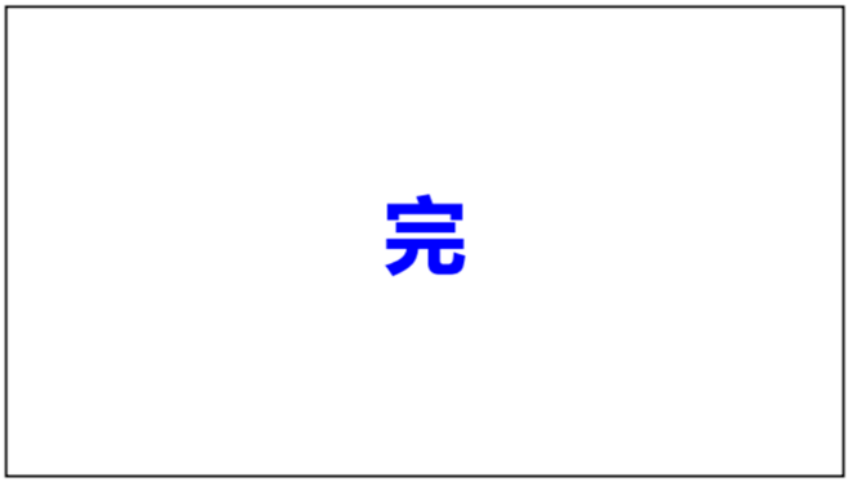


18

遊戲玩法

回合開始

抽取身分牌，根據身分牌抽取指定數量手牌。

階段一：資源收集

根據坐位順序，自由選取任何兩張資源卡作手牌。

階段二：協議討論

一位玩家代抽取三張協議卡。

1. 先翻開三張協議卡，根據協議內容作出討論和分析
2. 2 分鐘後舉手投票，選定一張協議卡執行

備註：

1. 協議卡分數各有不同（1/2/3 分）。
2. 分數越高，資源要求數量越多。

討論方向：
-選取哪一張協議卡？
-有足夠資源完成協議嗎？
-每一個國家分別負責多少資源？
-三回合後能否達到

階段三：執行議案

執行階段開始
大家同時間把資源卡放置身分牌上，進行結算。

情況一：資源牌數量不足
直接列作失敗

情況二：資源牌數量足夠
確定議案通過

階段四：回合結束

回合結束，重複回合，三回合後進行結算

結算內容：

1. 協議卡總分
2. 個人手牌總數

9.4 Motivational test

課後評鑑問卷 (學生填寫)

班級: 性別: 男 / 女

這份問卷所得資料主要用作學術研究用途，希望你能根據課節的實際情況作答。請仔細閱讀下列句子，然後在適當的空格內加上“✓”。 此問卷以不記名方式填寫，所有資料絕對保密。

	完全同意	非常同意	稍微同意	非常不同意	完全不同意
1. 我喜歡此課節的學習模式。	□	□	□	□	□
2. 老師所用的教法生動有趣。	□	□	□	□	□
3. 我投入此課節的活動。	□	□	□	□	□
4. 此課節的教材能引起我的注意力。	□	□	□	□	□
5. 此課節引起我對地理科的學習動機。	□	□	□	□	□
6. 我曾詢問與地理課程內容有關的其他知識。	□	□	□	□	□
7. 此課節的學習目標十分清晰。	□	□	□	□	□
8. 此課節所學的知識與現實生活有直接關連。	□	□	□	□	□

9. 此課節讓我更關注全球暖化議題及國際間的對策。	□	□	□	□	□
10. 我能夠將此課節所學的知識應用於了解及分析國際合作上。	□	□	□	□	□
11. 我完全掌握此課節所學的知識。	□	□	□	□	□
12. 我有信心能說出國際就全球暖化定下的協議及內容。	□	□	□	□	□
13. 此課節增加我地對地理科學習內容的了解。	□	□	□	□	□
14. 如果我努力學習，我會在地理科中表現良好。	□	□	□	□	□
15. 我很開心能夠完成課節中的各項任務。	□	□	□	□	□
16.我很開心能夠參與此課節。	□	□	□	□	□
17. 在得到老師或同學的讚美時，我感到自豪。	□	□	□	□	□
18. 老師或同學的正面回饋對我在地理科學習上很重要。	□	□	□	□	□
19. 我較懂得積極地面對難題。	□	□	□	□	□
20. 我樂意在小組活動中分擔一部分工作。	□	□	□	□	□
21. 我懂得如何在小組活動中和組員合作。	□	□	□	□	□
22. 總的來說，我對此課節活動感到滿意。	□	□	□	□	□
23. 我參與這個課節沒有感到壓力。	□	□	□	□	□

你對這個課程活動有其他意見嗎?(例如:活動量、習作安排、使用的教具等)

謝謝!

9.5 Motivational test (for analysis)

課後評鑑問卷: 供分析用

班級: 性別: 男 / 女

這份問卷所得資料主要用作學術研究用途，希望你能根據課節的實際情況作答。請仔細閱讀下列句子，然後在適當的空格內加上"✓"。 此問卷以不記名方式填寫，所有資料絕對保密。

		完全同意	非常同意	稍微同意	非常不同意	完全不同意
注意	1. 我喜歡此課節的學習模式。	□	□	□	□	□
	2. 老師所用的教法生動有趣。	□	□	□	□	□
	3. 我投入此課節的活動。	□	□	□	□	□
	4. 此課節的教材能引起我的注意力。	□	□	□	□	□
	5. 此課節引起我對地理科的學習動機。	□	□	□	□	□
	6. 我曾詢問與地理課程內容有關的其他知識。	□	□	□	□	□
相關	7. 此課節的學習目標十分清晰。	□	□	□	□	□

	8. 此課節所學的知識與現實生活有直接關連。	□	□	□	□	□
	9. 此課節讓我更關注全球暖化議題及國際間的對策。	□	□	□	□	□
	10. 我能夠將此課節所學的知識應用於了解及分析國際合作上。	□	□	□	□	□
信心	11. 我完全掌握此課節所學的知識。	□	□	□	□	□
	12. 我有信心能說出國際就全球暖化定下的協議及內容。	□	□	□	□	□
	13. 此課節增加我地對地理科學習內容的了解。	□	□	□	□	□
	14. 如果我努力學習，我會在地理科中表現良好。	□	□	□	□	□
滿足	15. 我很開心能夠完成課節中的各項任務。	□	□	□	□	□
	16.我很開心能夠參與此課節。	□	□	□	□	□
		完全	非常	稍微	非常不同意	完全不同意

		同意	同意	同意		
	17. 在得到老師或同學的讚美時，我感到自豪。	□	□	□	□	□
	18. 老師或同學的正面回饋對我在地理科學習上很重要。	□	□	□	□	□
個人成長及社交能力	19. 我較懂得積極地面對難題。	□	□	□	□	□
	20. 我樂意在小組活動中分擔一部分工作。	□	□	□	□	□
	21. 我懂得如何在小組活動中和組員合作。	□	□	□	□	□
對課程整體意見	22. 總的來說，我對此課節活動感到滿意。	□	□	□	□	□
	23. 我參與這個課節沒有感到壓力。	□	□	□	□	□

你對這個課程活動有其他意見嗎?(例如:活動量、習作安排、使用的教具等)

謝謝!

9.6 Knowledge test

1.請按以下國家的發展程度分類。

A. 中國	B. 美國	C. 印度
D. 俄羅斯	E. 日本	F. 肯亞

已發展國家：_____ 發展中國家：_____

2.請就下列協議及相關內容配對。

德班氣候會議	淘汰有毒的化學冷卻劑-氫氟碳化合物(HFC)。
京都議定書	設立綠色氣候基金協助貧窮國家。
蒙特婁議定書	所有國家都同意合力將全球平均氣温的升幅限制在比工業化前的水平高2°C以下。
基加利修正案	設立「配額買賣制度」。
巴黎協議	已發展國家和發展中國家應先後淘汰化學物質氯氟烃（CFC）。

3. 儘管需要國際合作才能對抗氣候變化，但已發展國家和發展中國家在承擔氣候變化責任的問題上出現分歧。以下為部分爭議點：

(請圈出正確答案。)

a. (已發展國家 / 發展中國家) 比較早已開始發展，大部分温室氣體都是由(已發展國家 / 發展中國家) 製造的。

b. (已發展國家 / 發展中國家) 缺乏資金和技術對抗氣候變化。

c. 國家發展程度不一，視對抗氣候變化為國際責任並不公平，無疑剝削了(已發展國家 / 發展中國家) 經濟發展的權利。

d. 國際會議部分條文涉及協助他國發展，額外開支妨礙(已發展國家 / 發展中國家) 的經濟發展和降低人民生活水平。

e. 國際會議部分條文 (已發展國家 / 發展中國家) 無須承擔任何責任，對 (已發展國家 / 發展中國家) 有欠公允。

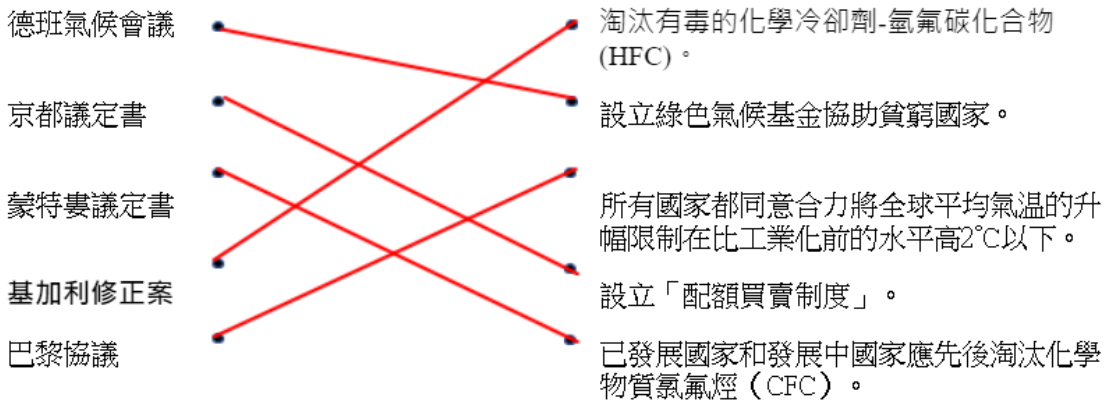
9.7 Knowledge test (answer)

1. 請按以下國家的發展程度分類。

B. 中國	C. 美國	D. 印度
E. 俄羅斯	F. 日本	G. 肯亞

已發展國家： B., D., E.　　發展中國家： A., C., F.

2. 請就下列協議及相關內容配對。



3. 儘管需要國際合作才能對抗氣候變化，但已發展國家和發展中國家在承擔氣候變化責任的問題上出現分歧。

以下為部分爭議點：(請圈出正確答案。)

a. (已發展國家 / 發展中國家) 比較早已開始發展，大部分温室氣體都是由(已發展國家 / 發展中國家) 製造的。

b. (已發展國家 / 發展中國家) 缺乏資金和技術對抗氣候變化。

c. 國家發展程度不一，視對抗氣候變化為國際責任並不公平，無疑剝削了(已發展國家 / 發展中國家) 經濟發展的權利。

d. 國際會議部分條文涉及協助他國發展，額外開支妨礙(已發展國家 / 發展中國家) 的經濟發展和降低人民生活水平。

e. 國際會議部分條文 (已發展國家 / 發展中國家) 無須承擔任何責任，對 (已發展國家 / 發展中國家) 有欠公允。