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A Guideline for Environmental Games (GEG) and a randomized controlled evaluation of a game to increase environmental knowledge related to human population growth

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Abstract

People often have very little knowledge about the impact of unsustainable human population growth on the environment and social well-being especially in developing countries. Therefore, an efficient method should be explored in order to educate, and if possible, to convince the members of the public to realize the environmental and social problems caused by the unsustainable population growth. Digital Game-Based Learning (DGBL) has been highlighted by some studies as an innovative tool for learning enhancement.

While only a handful of studies have scientifically evaluated the impact of DGBL on knowledge outcomes, the approach is an attractive tool to increase knowledge and motivate engagement with environmental issues surrounding population growth because of its potential to improve learners' motivation and engagement thereby compared to traditional learning approaches.

Therefore, the three primary research questions for this study are: 1) "Can a single-player digital game be an appropriate and attractive learning application for the players to gain insight about the relationship between the growing human population and the environmental issues?" 2) "How can we design environmental games for the players to gain insights about the relationship between the growing human population and the environmental issues via playing a game?" and 3) "What are the obstacles preventing the players from adapting environmental knowledge obtained from the learning mediums into the real-life?"

To inform the development of an efficacious DGBL game to impact learning outcomes, critical reviews of environmental issues related to population growth as well as critical reviews of commercial and serious environmental games in terms of their educational and motivational values were undertaken in this study. The results of these critical reviews informed the development of a Guideline for Environmental Games (or GEG). The GEG was developed by combining the engaging game technology with environmental learning and persuasion theories.

The GEG was then used to inform the development of a prototype game called THE GROWTH; a single-player, quiz-based, city-management game targeting young adolescents and adults. Multiple evaluation methods of the game were used to answer the three key research questions mentioned earlier. These methods included: 1) The Randomized Controlled Trial approach (RCT) where the participants were systematically divided into the experimental and the control group respectively and their knowledge scores (quantitative data) compared and analyzed, 2) The

participants' abilities to recall and describe the environmental and well-being issues were collected and analyzed qualitatively using The Content Analysis method (CA) and, 3) The participants' overall feedback on the learning mediums was collected and analyzed to evaluate the motivational values of THE GROWTH itself.

To this end, THE GROWTH was evaluated with 82 Thai-nationality participants (70 males and 12 females). The results showed that participants assigned to play THE GROWTH demonstrated greater environmental and social-well-being knowledge related to population growth ($F(1,40) = 43.86$, $p = .006$) compared to the control group participants assigned to a non-interactive reading activity (consistent with material presented in THE GROWTH). Furthermore, participants who played THE GROWTH recalled on average more content presented in the game when compared to participants who were presented with similar content in the reading material ($t (59) = 3.35$, $p = .001$).

In terms of level of engagement, the study suggested that participants assigned to the game were more engaging with their learning medium on average when compared to participants assigned to the non-interactive reading activity. This is evidenced by the longer time participants spent on the task, the activity observed from participants' recorded gameplay, and their positive responses in the survey.

The semi-structured interviews used in this study highlighted the participants' attitudes towards the environmental, social, and technological issues. Although the participants' perceived behavioural intention towards the environmental commitments were not statistically differed between the two study group, their responses still provide some evidences that leaps may occur from the learning mediums to the real-world context. Furthermore, these responses can be valuable evidences for the policy makers and for the future development of environmental serious games.

Overall, the results suggested that digital environmental games such as THE GROWTH might be an effective and motivational tool in promote the learning about sustainable population size, the environment, and the social well-being. The game's ability to convince the participants to change towards sustainable lifestyles, however, might be subjected to the future research and other real-world circumstances such as the governmental and public supports.

In summary, the research in this thesis makes the following contributions to knowledge:

- The Guideline for Environmental Games (GEG) contributes to knowledge about making theoretically-based environmental games. It has particular significance because the guideline was validated by demonstrating learning improvements in a systematic randomized controlled trial.

- The use of Multi-Strategy Study Design where multiple systematic evaluation methods were used in conjunction to provide conclusive findings about the efficacy of DGBL to impact outcomes.

- THE GROWTH itself is a contribution to applied research as an example of an effective DGBL learning tool.

Keywords

Bangkok, Blocked Design, Biodiversity, Commercial games, Content analysis, Control Group, Digital game-based learning, Ecosystem, Environmental games, Experimental Group, Game-based learning, Multi-strategy design, Pre-test, Post-test, Random assignment, Randomized controlled trial, Serious games, Sustainability, Thailand, Two-way repeated ANOVA, Unsustainable population growth

Abbreviations & Definitions

1) **2D Games:** Games that relied solely on 2-dimensional, pre-rendered images for graphical presentation. These games usually require minimal / medium system speed to operate which could potentially facilitate the distribution of 2D game applications to the general public and across different computer devices (e.g. mobile phones and tablet computers). The lack of realistic graphical presentation is the chief shortcoming of 2D games, however.

2) **3D Games:** Games that relied entirely or mainly on 3-dimensional projection software & hardware for graphical presentation. Depending on the development scales, 3D games can be very realistic in their graphical presentation (e.g. 360-degree camera movement, realistic game objects, special lighting effects, and physics. 3D games can provide engaging game experience to the players, but usually at the cost of higher system requirement (e.g. expensive computer system running at extra electrical energy).

3) **#P1-EXP:** This is the identifier format for participants used during the interview analysis. In this example, #P1 stands for participant No.1 and the -EXP extension signifies that the participant was from the experimental group. On the other hand, the -CTRL extension signifies that the participant was from the control group.

4) **Experimental sessions:** refer to all sessions conducted between the researcher and a participant.

5) **Gameplay Observation (recorded gameplay):** The software was used to record participants' progress while using THE GROWTH. The records could provide insight into matters such as learning curve, interaction with game functions, performance, level of engagement, and flaws in the game design. This method is only applicable to the experimental groups.

6) **GUI:** Graphical-User-Interface – a mean for the users to execute commands and receive feedback from the computer software visually.

7) **Learning mediums:** the collective term for two learning mediums used in this study. These being THE GROWTH (the game) and the book (the reading material).

8) **NPC:** Non-Player-Characters. The computer-controlled game characters representing humans, animals, robots, and others. The players may interact with NPCs in the game. For example: engage in dialogue conversations with human NPCs.

9) **QUIS:** Questionnaire for User Interaction Satisfaction. It was developed by The University of Maryland Human-Computer Interaction Lab. This survey questionnaire was used to understand the experimental group participants' reception towards THE GROWTH.

10) **Reader Satisfaction Questionnaire:** Serving the similar purpose to the QUIS, the Reader Satisfaction Questionnaire was used to understand the control group participants' reception towards the reading material.

11) **Reading material:** a book containing similar textual and graphical information to the game. It was used as the learning medium for participants assigned to the control group.

12) **THE GROWTH:** a prototype single-player, city-management, digital game used as the learning medium for participants assigned to the experimental group.

13) **The region:** a hypothetical, unnamed island nation in THE GROWTH serves as the game's central setting. Other regions also exist which form the world of THE GROWTH (described in lesser details).

14) **Time-On-Task:** The amount of time that the participants have spent on their respective learning mediums.

Aims & objectives

This project recognizes growing human population as one of the main factor in environmental degradation. As the benefits offered by utilizing game technology for educational purposes have been recognized, this project aims to: 1) Investigate approaches that can be used for the creation of environmental games, 2) Develop a prototype environmental game with a special focus on growing human population, and 3) Evaluate the effectiveness of the prototype game in term of knowledge outcomes, usability, motivation, satisfaction, and possibility of behavioral intentions.

The game developed for this project is a single-player, role-playing, management game. Its main concern is the growing human population and its impact on natural environment. By extension, the socio-economic implications which stem from human population growth are included into the game. Players assume the role of the leader of an environmental organization working closely with the government to maintain positive environmental conditions within the region. At the same time, social and economic aspects are important elements and can influence the game world in different ways.

The content for this game have been based on real environmental and social situations around the world. Because environmental problems such as pollution and radiation can spread from one region to another (e.g. Thairath 2012a, Scitable 2014), it is important to create a game scenario that recognizes the global effects. However, the game devotes special attention to environmental and social situations in Thailand where target participants were recruited for the experimentation. The main reason for this content-specific approach is to emphasize on specific geographical and cultural aspects of target region[1]. This approach can be linked to the concept of 'Situated Learning' (Prensky 2007: 161).

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[1] For example, the game scenario may visualize a region with abundant solar capacity to demonstrate the advantage of solar energy in Thailand (Chulalongkorn University Research and development support division 2008). However, because the game will also look at global perspective, regions with abundant wind and wave capacity that resembles energy advantage in United Kingdom (Goodall 2008) could also be introduced. Further, different environmental policies can also be discussed (e.g. practice of feeding portions of food waste to livestock in US and Thailand compared to organic waste-to-energy policy in United Kingdom).

1. Literature Review

1.1 Introduction

This chapter discusses the core rationale for this study: the environmental, social, and well-being issues stemmed from the unsustainable consumption of natural resources and human population growth. This chapter then presents evidence on the plausibility of using game applications (both commercial and serious games) to enhance the players' learning and motivational outcomes in the context of environmental conservation with the hope to equip the public with environmental knowledge and, if possible, persuade them towards the sustainable lifestyles.

Towards the end, this chapter presents the three research questions that resulted from the literature review investigation. These three research questions serve as the direction for this study. As this study is investigating the use of a serious game application in the environmental learning context, the three research questions are concerning with the knowledge gains, the motivational factors, the observation of game elements influencing the learning and motivational outcomes, and the perceived behavioural intentions of the players after using an environmental game application.

1.2 Overview on the environmental issues & environmental learning

Ecological degradation and environmental problems are urgent global issues (OECD 2008). Recently, global environmental problems have gained significant recognition from corresponding agencies including scientists, governments, and environmental organizations worldwide. It is generally accepted that most environmental problems may be attributable to human activities. Examples of negative environmental impacts caused by human activities include: unsustainable expansion of human habitats, resources extraction and consumption, pollution, and environmental contamination. Apart from these, rapid population growth is considered one of the key factors that accelerate ecological degradation. In turn, environmental degradation caused by human activities will escalate risks of environmental disasters in which the impacts will be reflected back to humans (Government Office for Science 2012, Washiravongsakorn 2012, Weerawattananon 1998).

Environmental degradation can trigger disasters that lead to catastrophic impacts on the livelihood of human population. The United Nations Office for the Coordination of Humanitarian Affairs (UNOCHA) has reported that the magnitude of population being affected by disasters in 2008 was increased from the previous decade by 41.1% (UNOCHA 2008). Also, about 70% of disasters are climate related, with scientists expecting a future increase in the rate of disasters (UNOCHA 2008). Populations with insufficient social security and located in risk areas are

especially vulnerable to unpredictable disasters due to the fact that they do not have the necessary power and resources to safeguard against disasters (STERN 2006: xxii, OECD 2008: 6, The World Bank 2010: 6).

Apart from regulatory and governmental policies, cooperation from the public (as general consumers) is vital to environmental conservation efforts. Coyle (2005: 55), for example, has suggested the long-term financial and health benefits from environmental conservation. For this, it is necessary that environmental conservation information must reach the public in order to promote environmental awareness.

Traditionally, environmental conservation knowledge is usually administered to the public via classroom-based lectures (usually not a mandatory subject). Outdoor environmental conservation activities are also practiced to some extent. More recently, other strategies such as game theories are being used to promote environmental awareness. Simulation systems, Game-Based-Learning (GBL), and Digital-Game-Based-Learning (DGBL) are considered by many researchers as attractive learning device (e.g. Kirts, Tumeo and Jeanne 1991, de Vries 1998, Torres and Macedo 2000, Hansmann et al. 2005, Martin et al. 2007, Diah et al. 2012, Valkering 2012).

Apart from the purpose of environmental conservation, games and simulation are being deployed in other fields of studies such as business training (e.g. Cesim 2012, Prensky 2007: 228), health care and well-being (e.g. Baranowski et al. 2003, Kato et al. 2008), and military simulation (e.g. Blunt 2007, Bohemia Interactive 2011). Game-based learning activities can be attractive to learners because they can entertain and educate learners simultaneously. In the case of Digital-Game-Based-Learning, advanced computer technology has made it possible for developers to produce computer games with high levels of fidelity and complexity (e.g. Prakash et al. 2009).

For this, games could be used as supplemental devices that allow learners to gain knowledge in "a more interactive way" (Diah et al. 2012). Similarly, Hilgard's principles also supported learners to take active roles in learning (Knowles, Holton and Swanson 1998: 74). Many individuals also find games to be enjoyable (Connolly et al. 2012; Ozcelik, Cagiltay, Ozcelik 2013) and motivating (Ozcelik, Cagiltay, Ozcelik 2013, Prensky 2007). Research suggests that computer games can be used to promote awareness (Diah et al. 2012), enhance learning capability (Arslan et al. 2011, Blunt 2007), and improve motor skills and alteration of behaviours (Baranowski et al. 2008).

Environmental games come in many settings and genres. Some environmental games take the form of table-top, board game such as ENVIROPOLY (see Arslan et al. 2011) and DEEP SEA DESPERATION (GREENPEACE 2010). Some environmental games also come in the form of digital packages. Examples of environmental computer games include FLOODSIM (PlayGen

2008), FATE OF THE WORLD (Red Redemption 2011) and ANNO 2070 (Ubisoft 2011). Presentation and mechanisms in these games vary for example some games use turn-based mechanism (similar to traditional paperboard games) while others use real-time approach; some are based in the real-world while others depend on interpretation of possible scenarios.

Despite the impression that Game-Based-Learning can be used as a supplementary device to formal education, there are still on-going discussions within research communities regarding of effectiveness of Game-Based-Learning applications (Erhel and Jamet 2013). While research has demonstrated positive outcome of using games for teaching knowledge and skills, others have reserved opinions regarding the beneficial effects from using Game-Based-Learning (Egenfeldt-Nielsen 2007, Squire et al. 2005). In an environmental context, Coyle (2005: 61), for example, has suggested that environmental awareness can be enhanced when participants are exposed to outdoor and environmental conservation activities.

1.3 Terrestrial ecosystems

In natural scenarios, many plants and animal species have become extinct due to the process of natural selection. However, human activity has contributed to significant amounts of pollution, an increase resources extraction (de Fraiture 2010, The Zoological Society of London 2014), and the destruction of natural habitats (e.g. Laurance 2014). These activities have accelerated the extinction of other species (McMichael 1993, Galetti and Dirzo 2013, The Zoological Society of London 2014). The impact of human activity on the natural environment has been widely confirmed (e.g. Donohoe 2003, McMichael 1993, OECD 2008, Steadman 1997, Wilson 1989).

Global human population has expanded rapidly since the introduction of agriculture (The Floating University 2012). And in 2011 was estimated to have reached seven billion (United States Census Bureau 2011). From an environmental perspective, this means an enormous pressure is being put on the planet. Both renewable and non-renewable resources are being extracted and depleted at a rapid pace. Deforestation, loss of biodiversity, habitat destruction, air and water pollution, soil contamination, and urban expansion are evidence that human activities are contributing negative impacts on the natural environment at a global scale. Studies have also indicated that growing human population is one of the main driving forces for rapid ecological degradation (Donohoe 2003, Gardner et al. 2010, Guillebaud 2007, Hanjra and Qureshi 2010, Messerli et al. 2000, Pimentel and Pimentel 2006, Richardson and Loomis 2009, United Nation Population Division 2011, Laurance 2014).

There are concordances between growing human population and environmental degradation. For example, the major reason of deforestation is the need to expand farmlands to satisfy the food demands of a growing population (Pimentel and Pimentel 2006, National Geographic n.d.). At

the same time, the majority of the global fresh water supply is being diverted for agricultural projects (IMECHE 2013: 3). Further, food producers are utilizing toxic pesticides to secure agricultural products. In turn, this contributes adverse impacts on the natural environment, local wildlife, and even consumers (United States Environmental Protection Agency 2012b). Further, a study has suggested that much of the farmland around the world is being contaminated and damaged by agricultural intensification and soil degradation (Tscharntke 2012).

Soil salinization in croplands is considered a widespread and important environmental problem (Masoud and Koike 2006). The problem causes approximately 10 million ha to be lost each year (Thomas and Middleton 1993). The problem can be magnified by intensive use of pesticide and fertilizers. Major causes of soil salinization include clearing trees for agriculture and poor environmental management (Deehan and Taylor 2002). Soil degradation not only damages the environment, but also reduces food productivity and contributes to long term economic loss. In addition to continuing deforestation for new farmlands, forests around the world suffer from illegal logging where trees are cut down and sold. Moreover, forests are being cut down for fuel wood. A study has estimated that more than one billion people in developing countries are relying on fuel wood for heating and cooking (Tucker 1999) – a major implication for forest protection efforts.

The loss of biodiversity is attributed to rapid deforestation. It is important to recognize biodiversity as functioning body of a balanced ecosystem. Forests are often very bio-diverse and very valuable for the biological studies of complex relationships between species. Tropical rainforests are especially valuable as they contain the majority of Earth's species (Donohoe 2003).

From 2000-2005, over 12,949,940 ha of tropical rainforest in Brazil have been lost to deforestation (National Geographic n.d.). Many of the remaining forest lands around the world are at risks of being destroyed by logging and harvesting of non-timber products. There are immediate gains from exchanging the product of forest for short-term wealth creation. This is often driven by poverty in local communities and the weakness of environmental conservation (Gregg 2011). Often, this results in a long-term impact on the natural environment. Further, many species are unique to certain habitats and hence, it is almost impossible to restore destroyed forests back to their original stages. Environmental restoration projects can be politically challenging, time consuming, and laborious. The cost for recovering degraded forests and natural habitats is very high with no guarantee of success on environmental restoration projects (Gardner et al. 2010, Yagodin and Oganessian 2008).

Human activities may alter the ecosystems. For example, the introduction of non-native species into natural habitats can cause enormous impacts to the environment (Phillips et al. 2012, Wilson

1992). Exotic pet owners may, for example, unknowingly release exotic animals into an opened environment. These non-native species can effectively compete against native species for resources and spawning areas. Some non-native species are voracious hunters that prey upon and drive native population into extinction. Also, there are examples of non-native species that carry non-endemic diseases, exposing native species to new parasites and pathogens (Index2you 2009, Phillips et al. 2012, Steadman 1997) and putting native species at risk of extinction (Steadman 1997).

Healthy ecosystems, on the other hand, are important not only to wildlife, but benefit humans as well (vanEngelsdorp and Meixner 2010, Kopnorkkala 2012). Biological control (i.e. using natural predators to eradicate pest animals) can reduce the cost of expensive pesticides, preserve soil conditions, and promote food safety. Further, biological control also spares 'non-target' species (animal species that are not considered as pest) that would otherwise be affected by harmful pesticides (e.g. Snyder et al. 2004, Thairath 2013). Thus, hazardous pollutants diminish useful insect populations and decrease agricultural productivity. Preservation of non-target species, on the other hand, is important as many important commercial crops are also highly dependent on insect pollinators (Krishnan et al. 2012, Preiser n.d., vanEngelsdorp and Meixner 2010).

Natural environments are very important to humans as they generate steady supplies of natural resources over time. Pharmaceutical components, for example, can be derived from tropical rainforests (McMichael 1993). Further, enormous, undiscovered and untapped sources of genetic materials lie in the ecosystem of reefs which represent significant opportunity and potential for medicinal and agricultural uses (Reaka-Kudla 1997).

1.4 Marine ecosystems

The ocean ecosystem is very important yet largely unexplored. Toxic components contribute serious threat to the marine ecosystem. Mercury, for example, can be found in marine species especially shellfish and deep sea bottom feeders. A study has suggested that heavy industries are responsible for much of mercury contamination in marine environment (Burger and Gochfeld 2011).

Coral reefs for example, are considered as both biological indicator and natural habitats for many marine species. However, coral reefs are being endangered by human activities (Nyström et al. 2000). Other marine species are being threatened by human activities as well. Causes for declining marine ecosystem include overexploitation, pollution, deforestation, and runoff from agricultural sectors (Reaka-Kudla 1997).

1.5 Pollution

Wastes and pollutants are also considered as major environmental problems. In 1997 America alone produced over 430 billion pounds of garbage (Gavzer 1999). Large amount of this has ended up in marine environments with an estimated 80% of garbage in the oceans coming from land-based sources (Marine Debris Program 2012).

Garbage can be incinerated, but not without generating air pollution. Thus, the activity contributes to environmental degradation (Donohoe 2003). Garbage dumped into landfill also produces leechate (garbage juice). Improper disposal of garbage causes leechate to seep into deep earth, contaminating soils and water channels.

1.6 Energy consumption

Many countries are still relying on fossil fuels which contribute significant impacts to the environment (OECD 2008). Global energy consumption from fuel and electricity is projected to increases in the near future (EEA 2005). Much of global energies are derived from non-renewable energy sources. Energy is not being used efficiently. For example, it is estimated that food in the US has to travel for over 2,000 km. from production sites to reach consumers - roughly 4 Kcal of fuel energy for every Kcal of food consumed (Ourenergyfutures 2010). Also, attempts to devote more lands for biofuel production can contribute both direct and indirect impacts on food security and natural environment (Gasparatos, Stromberg, Takeuchi 2011).

In summary, the increasing demand of resources from growing population has magnified pressures on the natural environment. Resources are being extracted from both terrestrial and marine sources at rapid pace. Portions of fertile lands and woodlands are being transformed for human uses. Many plants and animal species are being at risk of extinction due to combined effects of overexploitation, loss of habitats, pollution contamination and other human activities. To this, environmental problems must be recognized as a global issue as the problems can spread out from one region to another (e.g. Thairath 2012a). Further, resources scarcity and unsustainable resources consumption can be linked to severe social impoverishments (Donohoe 2003), possibility of conflicts, and war (e.g. Le Billon 2001, Ross 2004).

These issues have been incorporated into the game through the presentation of textual information as well as game mechanism as shown in THE GROWTH chapter.

1.7 Growing human population: Health, social, and economic aspects

Apart from environmental issues, unsustainable growth of human population can also contribute negative societal impacts. In this section, the link between growing human population to health, societal, and economic issues is explored.

There is no universal indicator to determine the carrying capacity for world population (i.e. the maximum amount of human populations that the earth could support). Reasons can be attributed to a number of factors such as differences in cultural and societal parameters around the world (Cohen 1995, ECSPWWC 2010). For example: the planet's ability to support the human population could be increased if sustainable consumption and lifestyles were adopted.

Figure 1.1: Cohen (2011)'s Population Bathtub Theory, highlighting the relationship between birth and death rate. Modified and reproduced with courtesy of Adam Glick, the co-founder of The Floating University

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According to a report, more than 900 million people were undernourished in 2010 with 98% of this figure living in developing countries (The Floating University 2011). The feasibility of adjusting global consumption pattern toward vegetarianism (as a more environmental-friendly consumption option) remains remotely possible as records have previously demonstrated an increase in both the supply and demand for meat stocks (e.g. Heinz and Hautzinger 2007, World Watch Institute 2011, Laurance 2014). On the other hand, enormous amount of foods are being wasted globally which represents both unsustainable resources consumption and pollution impact on the natural environment (e.g. IMECHE 2013: 3, Inhabitat 2013).

Fresh water is an essential, life sustaining resource. It is reported that about 5 million people in South Africa lack access to water while another 15 million people lack access to basic sanitation (The Water Project 2013). Another report has estimated that as much as 4 million people in New Delhi of India do not have access to running water (Howstuffworks 2012). Similar water shortages occur elsewhere in the world and may be attributable to a combination of mismanagement, climate change, and contamination of water sources. Further, water shortage

can affect agricultural outputs and thus, amplifies the risks of malnutrition and famines (FAOWATER n.d.)

It is important to recognize that population size alone cannot be used as the sole indicator for the level of environmental degradation. In some cases, developed countries have generated a greater amount of carbon emissions per capita when compared to developing countries (Vaughan 2009). From this data we can see that the population in developed countries is also responsible both directly (e.g. industry) and indirectly (e.g. imported products) for the large amount of pollution emission.

Apart from the impact on the natural environment, the unsustainable growth of human population can impede social development and quality of life in many ways. For example, some studies have suggested that the unsustainable growth of human population can lead to economic loss and poverty (United Nation Population Division 2011: 6, 16, Guillebaud 2007).

Education can be a necessary means to reduce fertility. A study has suggested that education can have a greater influence on fertility than income (Handa 2000). Similarly, other researchers have found that schooling not only prevented unplanned pregnancy in young mothers, but also continued to maintain similar influences later in lifetime (Cygan-Rehm and Maeder 2013). Researchers have suggested that higher number of children per family can lead to health impacts of both mother and children (United Nation Population Division 2011: 2, The Floating University 2012). The risk is amplified in families with low-income and low social security. Further, high rates of life-threatening diseases such as HIV in poor regions can be attributed to insufficient and / or false information (Siegler et al. 2012). Apart from sexual education, general education is essential for women's empowerment (McDougall and Guillebaud 2010, Osili and Long 2008, The Floating University 2012).

Interestingly, formal education and academic performances alone cannot be used to influence family planning in some cases. A 2012 report from the Thai Department of Mental Health (DMH) has suggested there are approximately 300,000 cases of unintended pregnancies in young female teenagers per annum. About half of this had used illegal abortion services (Thairath 2012f). According to the report, the majority of these are female teenagers with relatively high academic performances. DMH has suggested from their studies that the high rate of unintended pregnancies in Thai teenagers could be attributed to the fact that this teenager group can perform academically, but lack important social skills. They are unable to negotiate with their male partners to use protective measures (i.e. condoms), unable to obtain contraceptive devices, unable to discuss the issue with parents, and have insufficient knowledge on contraceptive devices (Thairath 2012f). Also, it should be noted that unintended pregnancies in Thailand could be attributed to the fact that pre-marriage sexual relationship are considered as 'shameful' and

'social taboo' by many (Kapook 2013). In other word, contraceptive devices are readily available from pharmacies in Thailand at a reasonable price, but many teenagers find it difficult to make a face-to-face purchase from the stores or are afraid of being discovered by parents and friends (personal observation). This highlights the dilemma between social values and methods for fertility control.

However, family planning should not be limited only to developing and densely populated countries. For example, researchers have suggested that about half of the total births in USA were unintended (Finer and Zolna 2011, The Floating University 2012). This emphasizes that family planning should be promoted globally in order to minimize social problems and encourage healthy population. Interestingly, a recent study in India has suggested that access to media platforms such as cable television can influence and persuade women to reduce the number of their children by showing them different cultural and social lifestyles (Jensen and Oster 2009). This highlights the possibility of using multimedia platforms to influence behavioural change.

1.8 Technological aspects

At the heart of human civilization is the research and development of new technologies that can be used to our advantages. Technologies can improve the livelihood of a population in many ways. Automation technologies for example, can accelerate overall productivity while decreasing the operational cost associated with a labor force. Medical technologies can be used to improve overall quality of life. Other technologies are being progressively developed to improve energy efficiency, and minimize environmental impacts. From technologists' point of view, advanced technologies can be used to improve overall quality of life (e.g. bigthink 2012) as well as help reduce environmental problems.

However, technology must be used cautiously. Apart from its many benefits, technology can also promote rapid extraction and consumption of resources. 'Use-And-Throw-Away' items such as product containers and electronic devices often contribute to environmental pollution. Kaoleaung (2005) for example, highlights incoherence between the adoption of advanced technology and the failure in environmental conservation as a 'perfunctory development'. With growing demands from billions of consumers worldwide, the pressure is being magnified on the natural environment (Washiravongsakorn 2012). Plastic wastes, for example, have become an imminent threat to wildlife and the natural environment. As mentioned earlier, large percentages of plastic and other inorganic wastes have not been properly disposed of and have ended up in soil layers, river networks, and the oceans. There are also growing concerns over electronic and toxic wastes which are considered hazardous to the environment. In 2009, United States Environmental Protection Agency reported that only about 25% of consumer electronics had been collected for recycles (United States Environmental Protection Agency 2012a). Most of discarded consumer

electronic devices had been improperly disposed of in landfill (United States Environmental Protection Agency 2011).

For this, environmental impacts from unsustainable products were included into the game. At the same time, the benefits from sustainable and efficient technologies are included.

1.9 Games targeting environmental, social, and health issues

1.9.1 Serious Games targeting environmental issues

Prior to the environmental game development, the researcher has consulted with existing serious and commercial games to understand the importance of each game mechanism.

There are a number of environmental games currently available. Environmental games can be developed under the band of serious games (with the focus educational and training purposes) or commercial games (usually with entertainment purpose)

Unlike commercial games, Games with learning contexts (especially digital games) have become increasingly sophisticated and complex due to advances in computer technology (Prakash et al. 2009). Further, boundaries between serious games, entertainment games, training games and simulation games have started to blurred (Dormann and Biddle 2009) as today's game can be both educating and entertaining. Types of games (e.g. strategy, role-playing, or action game) also vary from one game to another. However, a game can also include several aspects from different game types into their products[1].

Each environmental game attempts to tackle certain or multiple environmental issues. For example, JOM KITAR SEMULAR (JOKS) is a 2D top-down perspective view adventure game that attempts to promote environmental awareness specifically on recycling to primary school children (Diah et al. 2012). The game mechanism in JOKS operates on three stages which are: 1) navigate the virtual environment in order to collect recyclable items, 2) sort collected items into corresponding recycle bins and 3) proceed to the next level (Diah et al. 2012).

In JOKS players take control of a character in a quest to collect recyclable items scattered on the map. Players have to avoid enemies and obstacles while collecting items. With all items collected, players have to bring them back to a recycle station which also acts as a gateway for players to continue to the next phase and into the next level. When approaching a recycle station, players have to match the recyclable wastes they have collected earlier with the corresponding

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[1] Baldur's Gate II: Shadows of Amn (Bioware 2000) was a role-playing entertainment game that has also incorporated the aspect of business management where players take responsibility over decision-making process of a guild or a castle. Further, the game can be played either in a real-time or turn-based mode.

type of bins (e.g. put paper wastes into a blue bin and glass into a brown bin). When a level is completed, players move to the next level (with a different game environment and larger area). The learning concept in JOKS reflects the household recycling process in the real-world. However, JOKS also includes game elements such as rewards and punishment to attract and motivate players (e.g. rewards include additional lives and scores for completing a mission successfully. When players fail a mission they are moved back to a previous mission). The researchers were yet to test the educational value of the game at the time of this writing, however.

Mini environmental games (i.e. fast-paced and linear games designed to be completed by players in a relatively short time) have been designed to tackle specific environmental issues. Several of these games are relying on simple mechanisms which are based on existing and familiar rules of games in the past. For example, SORT YOUR WASTE (Kidsgoflash n.d.) is a mini recycling game that uses a 'drag-and-drop' mechanism. In SORT YOUR WASTE, random images of wastes are shown to players. Players then have to drag each waste in to its corresponding bin. For example, players have to drag-and-drop a banana skin into a bio-compost bin, a broken light bulb into a toxic waste bin and a glass bottle into a recycle bin. A score sheet is shown at the end of the game to provide feedback for players.

ENERGY EFFICIENCY TRUMPS (Glasgow Science Centre n.d.) is a digital card game which aims to inform players about energy consumption rates in electric appliances. In this game, players compare electrical consumption rates between two electronic appliances. For example, players compare electrical consumption rates between a vacuum cleaner being used to clean a room VS a desktop computer put on standby mode for a day. The game provides players with immediate responses (correct / wrong answer) for each round. Players are presented with final scores once they have exhausted an entire card deck (seven sets of cards).

CLEAN UP THE CLYDE (Glasgow Science Centre n.d.) is another 2D side-scrolling, action game with a relatively simple game mechanism. The game informs players about the management of water pollutants. In this game, players take control of a boat on a mission to pick up garbage and pollutants from the river. However, players must avoid taking native sea plants and animals while on the mission. Players will be presented with a final score by the end of the game.

CLIMATE CHANGE CHALLENGE (Glasgow Science Centre n.d.) is another environmental game with a relative simple game rule. This game incorporates a 'photo-hunt' game mechanism. In CLIMATE CHANGE CHALLENGE, players are presented with a large picture of a landscape with several objects such as flower beds, trees, and a car. On this, players will need to identify and mark on objects which represent the cause of environmental problems. For example, the player marks a nuclear power plant, a car, humans, and farmed animals in the picture as the

causes of environmental problems. The game uses a virtual advisor to provide extra information for players on each item marked by the player.

Some games were designed to tackle multiple environmental issues at global scale. FATE OF THE WORLD (Red Redemption 2011) is a turn-based, strategy, card game that attempted to tackle multiple environmental issues at the same time. FATE OF THE WORLD has received several awards including a 2011 Silver Award from Serious Play (Serious Play Conference 2013). Apart from environmental issues, the game also exposes players to economic, cultural and political aspects. Players take a role as the leader of an organization called GEO (Global Environmental Organization). Players are responsible for global environmental policies while social, economic, and political balances around the world must be maintained. FATE OF THE WORLD is based on cultural characteristics of civilizations in real-world (e.g. different levels of consumption and emissions across the globe). The game predicts into the future where advanced technologies can be used to benefit both human civilizations and the environment. Theoretical policies can be used to minimize environmental impacts although some policies come at the cost of disapproval from certain societies (e.g. funding environmental conservation projects will gain approval from population in eco-conscious regions while anger population in consumerist regions).

In FATE OF THE WORLD players also need to manage environmental and societal catastrophes of the future predicted by game developers (e.g. extinction of wildlife species and famine). HDI (Human Development Index) also plays important roles in some game scenarios where players must improve HDI level in certain region(s) in order to complete a mission and proceed to the next level.

BBC CLIMATE CHALLENGE (BBC – Climate Challenge n.d.) is a turn-based environmental card game focused on policy planning similar to FATE OF THE WORLD. The game is available for free online and can be played on standard internet browsers. The goal of this game is to set a target for CO_2 reduction and devise policies in order to achieve the target. There are four types of factors in this game: wealth, energy, food, and water. The game begins with players choosing their cards (policies) to play in a round. Some cards provide beneficial effects to certain issues, but cause negative impacts on others. For example, 'improve housing regulations' policy helps improve energy efficiency and the environment, but also drains wealth from treasury. This means players must choose policies carefully in order to maximize environmental benefits while refraining from exhaust other factors. Public approval is also an important aspect as it affects a player's reputation on an international forum. Some policies may contribute major benefits on the environment, but have adverse impacts on livelihoods of the population.

The game allows players to take into account public opinion (shown in pop-up menu) when choosing policies. For example, some of the game agents (representing members of the public) will agree with the 'improve housing regulations' policy based on the prospect of long-term energy saving. Other game agents, on the other hand, will express their dislike of this policy due to the substantial increase in construction cost.

Some environmental games come in a hybrid form. HONOLOKO (European Environment Agency n.d.) is an environmental adventure games that incorporated turn-based gameplay, adventure genre and a questionnaire-based game in one package. The game is available free online and can be played within standard internet browsers. The game is represented in a colorful design and allows for basic customizations (such as choosing a character to be players' avatar and then naming it). The game also employs 'light-hearted' narrative and feedback. Cheerful messages can be attractive and encouraging game elements for young children and teenagers (e.g. Dormann and Biddle 2009).

The game begins by positioning an avatar on a map. After this, the game asks players a series of condition-based questions. For example, a pop-up window tells players of facts about emission and health impacts from smoking in Europe. It then asks the player about their choices regarding someone smoking a cigarette in the room. To do this, players can choose between asking a friend for a cigarette, opening the windows, or telling a friend to quit and leave the room.

Answers can be categorized into different groups (health, fitness, energy, and resources). For example, the game asks which vehicle the player would use for transport on HONOLOKO Island. If the player chooses a bicycle, s/he gains 3 points toward resources, 3 points toward health and 3 points toward fitness. However, s/he gains 0 point toward energy. Also, player's avatar will be riding on a bicycle throughout the game. Upon the end of the game, a summary sheet gives players feedback based on their answers. Players can compare their results with other players around the world. According to the website, players can also enter their contact address for a chance to win a real-world reward – an example of transferring virtual accomplishment to real-world ones.

1.9.2 Commercial games targeting environmental issues

Some commercial-entertainment games also tackle certain aspects of environmental issues. ANNO 2070 (Ubisoft 2011) is a construction and management game (CMG) released in late 2011. The game has a background story of climate change and raising sea level that have affected civilizations around the world. Many cities have become submerged under the sea while landscapes had been transformed into chains of islands (as evidenced in game environment). The

game also has a story about two major human factions in the game. Each faction processes its own culture, lifestyle, and technological advantages.

The first faction is called 'Tycoon'. The Tycoon represents a consumerist culture where products such as meat, plastics, coal, and other superfluous consumables are being extracted and utilized at the expense of natural environment. Tycoon's faction is focused on economic growth and rapid expansion. The second faction is called 'Ecos' which represents environmental conscious population. Ecos relies more on renewable resources and contributes less environmental impacts when compared to the Tycoon faction (e.g. vegetarianism diets).

The third faction called 'Tech' is available to players of both factions at the advanced game stage. Members of this faction are scientists and technologists capable of devising advanced technologies to benefit human civilizations (and minimize environmental impacts to some extent).

ANNO 2070 features a relationship between population and resources. The game has over 25 types of both raw materials and finished products for each faction that must be satisfied in order to progress further into advanced stages. Managing growing population can be particularly challenging as large population drains various consumables and supplies at rapid speed, forcing players to expand into new untapped natural territories in order to extract more resources to sustain growing human habitats. New factories also need to be built in order to increase production capacity. In turn, newly built factories require electricity to operate. Both manufacturing and power stations contribute to pollution and emission which generates negative impacts on natural environment. In turn, critical pollution levels amplify the risk of disasters (which reflects back to human civilization).

ANNO 2070 has highlighted a number of environmental and social disasters. The majority of environmental impacts are caused by man-made activities. For example, 'smog' is a type of air-pollution caused by intensive industrial activities. It decreases population well-being and health problems. Another example of pollution is 'acid-rain', which caused by a severe level of air pollution. This significantly reduces agricultural productivity (which in turn, disrupts food networks and has a direct impact on the economy). Other environmental disasters such as radiation and oil leakage can occur if players operate nuclear reactors or oil platforms. However, advanced technologies can be deployed by players to minimize pollution and prevent disasters.

Therefore, ANNO 2070 demonstrates the relationship between human activities and the natural environment. Unfortunately, the game's scenarios are limited as such issues such as marine harvesting and systematic waste disposal have been under represented. Fish are a staple food source in the game, but harvest rate is determined only by the number of fishing boats. In other

words, a larger fishing fleet means fish can be harvested at faster rate (an abundant fish population is assumed in this game). Regarding waste disposal, 'waste compactors' (a type of in-game waste stations) can be built around residential areas in order to improve environmental conditions. Unfortunately, the game did not highlight the process of waste disposal[2].

With advanced technology, ANNO 2070 allows players to construct devices called 'resources re-fillers'. These devices can be used to replenish exhausting resources such as mineral and oil deposits. This feature might have been designed to facilitate long game sessions as well as provide replay value. However, it means that natural resources in Anno 2070 are virtually unlimited.

Another example of a commercial-entertainment game that demonstrates the relationship between population and food resources is FATE OF THE DRAGON (SQUARE ENIX 2012). This is a Real Time Strategy (RTS) game based on Chinese history during the 'Three Kingdoms' era. The game follows classic RTS game mechanism where players are in charge of base buildings, resources management, and military expansion. There are four types of food resources in FATE OF THE DRAGON which are: corns, meats, buns, and wine. Corn and meat are raw resources that need to be 'processed' into buns before consumption. Buns are stored in a storehouse and are withdrawn for consumption automatically (by garrisoned soldiers). Large armies can exhaust food supplies quickly. For this, players are required to pay close supervision over food stocks. On the other hand, wines are made from corns and are used to heal injured soldiers.

FATE OF THE DRAGON emphasizes on the logistical importance of supply and players are required to micro-manage it. Soldiers on military expeditions need constant supplies of foods, which must be delivered to them by 'supply wagons' (i.e. carts filled with food supply). Each supply wagon has a maximum carrying capacity (e.g. 500 units of foods and 500 units of wines each). In turn, supply wagons need to be re-supplied constantly by caravans of horses and workers who withdraw supplies from the city's storehouse and travel along the game's map to refill supply wagons. However, total absence of supply will weaken soldiers and reduce their combat performance instead of dying from starvation.

Food supplies play an important role in FATE OF THE DRAGON. This is in contrast to strategy games such as AGE OF EMPIRES series (Microsoft Studios 2011) and COMMAND & CONQUERS series (EA 2011) where resources are required for soldier recruitment, but only

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[2] This is in contrast to SIMCITY 4 (a construction and management game) where players are required to allocate areas to be used as landfill. Garbage delivered to landfills is processed by waste facilities. Extra waste facilities increase garbage processing speed.

once. For example, gold and foods are required for soldier recruitment in AGE OF EMPIRES, but players are not obligated to provide them with food supplies over time.

Apart from food resources, lumbers and iron ores are required for construction and tool makings. Lumbers can be obtained by cutting down the trees and iron ores from the mining operation. Both resources are considered non-renewable. Trees do not regrow in this game and deforestation can be evidenced in a long game sessions – forcing the players (and the computer controlled-AI) to gather these materials from distant locations.

Apart from demonstrating the relationship between population and food resources, FATE OF THE DRAGON also features disasters such as diseases, locust swarms (decrease in agricultural outputs) and earthquakes (damage to buildings). Apart from having a direct impact on players' army, disasters also require players to choose between giving away resources to boost a city's morale or ignoring the situation (at the cost of reduced morale).

Another commercial-entertainment game which features the relationship between population and food resources is STRONGHOLD: CRUSADER (Firefly Studios 2012). This is a castle-management game with a setting in desert civilizations during the Middle Age. As the lord of a castle town, players must manage both civil and military matters within the city. There are a number of raw resources available for players in this game. Foods are a type of resources and especially vital to players' power building. Similar to FATE OF THE DRAGON, population consumes foods over time and new stock must be replenished back into storehouses to sustain the needs.

In STRONGHOLD: CRUSADER, farms can be built to generate food for population. However, farms can only be built on fertile lands as the setting of the game in centered in arid environments (fertile lands are depicted in the game as grass patches). Foods produced from farms include cheese, wheat, hops, and fruits among the others. Some types of food such as wheat must be milled and baked into bread before it could be consumed. Apart from farms, meat is a type of food that can be gathered by sending out hunting parties. Animals are scarcely populated in this desert environment which limits hunting activities.

The population in this game expresses an increase in happiness if more than one type of foods is available for their consumption (e.g. bread and cheese). Alternatively, players can also adjust the amount of food rations to populations according to situations. 'Large food-rations' will boost population's level of happiness while 'half-ration' will have a significant impact on their morale.

The spread of infectious disease and risks of outbreaks is a major concern in urban setting (Government Office for Science 2012: 3). To this, STRONGHOLD: CRUSADER also highlights the impact of diseases on densely populated towns (in military scenario). For example, diseased

cows (a type of in-game disease attack) can be catapulted by the attacking party into a target castle. Soldiers in tight formations and citizens in densely populated areas will be affected by the disease. A similar concept has been demonstrated in COMMAND & CONQUER: TIBERIAN SUN (Gamefaqs n.d.), where areas with high-density population can be especially vulnerable to chemical attacks.

A number of serious and commercial-entertainment games with environmental aspects have embraced the construction and management genre (CMG). ENERCITIES (European Commission Programme Intelligent Energy Europe 2011) for example, is a serious game developed to tackle multiple environmental issues. The game can be accessed for free online and it is also linked to the social network website (Facebook). Because the game requires an online connection, players' data can be saved for the next access. The game also has a 'scoreboard' where players with high performances will be listed on the website which allows for competitions among players. In term of graphical representation, ENERCITIES has a relatively colorful artwork when compared to several other city management games which emphasize realistic representation such as SIMCITY 4 (Electronic Arts n.d.), IBM CITYONE (IBM 2012), PLAN IT GREEN (Nat Geo Games 2012), ANNO 2070 (Ubisoft 2011) and CITIES XL (Focus Home Interactive 2011).

At the start, ENERCITIES gives players an area which can be developed into a larger and more advanced city. It is important that players must balance between city expansion, economic growth, and environmental factors. Some buildings in ENERCITIES can be upgraded so their performance can be improved (e.g. blades of a wind generator can be upgraded in order to increase energy outputs). In terms of learning outcomes, ENERCITIES has been tested by participants and the outcome was favorable as the game helps improve participants' attitude and behavioural intentions (Enercities 2012).

PLAN IT GREEN (Nat Geo Games 2012) is another construction and management game sharing several similarities to ENERCITIES. PLAN IT GREEN allows players to develop a small suburban-liked village into an advanced town. Environmental emissions must be minimized in order to develop a successful town. To this end, players can improve existing buildings with environmental-friendly technologies such as installing solar panels on top of an office building or equipping a house with thermal paints. Tax revenues are generated by residents and deposited in the treasury automatically at regular intervals. Revenue is important as it is used for developing the town. There are two types of resources in this game which are building materials and wealth. Both are required in order to construct new buildings or purchase new items. The game also allows for customization of buildings in the town such as painting buildings with different colors.

ENERGYVILLE (Chevron-EnergyVille 2011) is another city management game developed by Chevron. The game is provided for free online. ENERGYVILLE focuses on simulating energy policies, their impact on the city and the world. Unlike other city building games such as PLAN IT GREEN and SIMCITY 4, ENERGYVILLE does not allow for free-form construction and expansion. ENERGYVILLE also makes extensive use of textual contents which give detailed information to players about each game object based on the real-world data.

Players start the game by deciding which energy sources will be used in order to provide energy to match the electrical demands of population living in a pre-defined town. Detailed information on each energy source is provided to help players in their decision-making. For example, a coal-fired power station is relatively inexpensive to build and maintain, but causes enormous environmental impacts and a medium-high impact on energy security. Apart from choosing energy sources, energy conservation policies can be implemented in order to reduce a city's power demands.

ENERGYVILLE has multiple stages. Each stage represents a timeline as the city moves forward into the future (e.g. stage one represents year 2015-2020 while stage two represents years 2020-2030). World events are shown to players upon entering a new era (e.g. terrorist attacks are putting pressures on oil supplies). Energy policies implemented by the player can trigger changes in demographics (e.g. economic growth might be put to a halt if players had previously enacted the energy conservation policy). In order to pass each stage, players need to satisfy the city with its electrical demands. Upon the completion of all stages, players are given a summary based on their performances and choices that they have made in the game. Players can compare their results with other players online.

Perhaps one of the most well-known construction and management game is SIMCITY series. SIMCITY 4 (Electronic Arts n.d.) is a commercial construction and management game that includes environmental issues such as air pollution, water pollution, and waste disposal.

Energy and water usage in SIMCITY 4 increases as the city grows. Increased resources consumption came from both private as well as public sectors. For example, expansion of industrial sectors requires greater levels of electrical and water supplies. Power stations also require access to water supplies. At the same time, new water pumps can be built in order to provide additional water supplies but also require electricity to function.

In respect to electricity in SIMCITY 4, there are a range of energy technologies available to players. For example, coal-fired power stations are relatively inexpensive to build, provide good energy output, and are inexpensive in terms of maintenance costs (when compared to other power station types). However, coal-fired power stations also generate significant amounts of air

pollution which is depicted in the game as smog. More environmental-friendly energy generation technologies such as solar collectors systems and wind turbines are available for construction. These renewable power generators cost more in term of maintenance. Wind and solar generators also produce less electrical outputs when compared to other fossil-fuel power stations.

Air pollution has health impacts on the population. This results in an increased amount of patients being admitted into hospitals. However, illness in SIMCITY 4 can be mitigated with relative ease (by building more hospitals in order to provide additional rooms for patients).

Water pollution is also featured in SIMCITY 4. Coastal areas affected with pollution are displayed with black patches above the water surface (possibly to depict waste spillage). Water networks in the city will be shut down once pollutions has exceeded a safety threshold. In this case, water treatment plants can be built to mitigate the problem.

Waste disposal is another environmental aspect featured in SIMCITY 4. Players have to allocate space(s) to be used as landfills. Wastes generated within the city are unloaded into designated landfills and accumulated overtime. Players have several options to mitigate waste problems which include: expanding the landfills, building recycle stations, and waste incinerators, and paying other cities to handle waste disposal for the players' city.

Recycle stations can help 'remove' deposited wastes from the landfill. However, the process takes a considerable amount of time. Multiple recycle stations can be built to mitigate waste problems in large cities (the drawback being increased operation costs). Waste incinerators, on the other hand, can remove wastes from the landfill faster when compared to recycle stations (burning wastes, incinerators also produce electricity). However, waste incinerators also generate air pollution. Lastly, players can ship their wastes over to other cities (by paying other cities for their services). While this is not considered as a 'true waste management' practice, this policy helps players mitigate waste problems in their cities.

Apart from construction and management theme, serious games addressing environmental topic can also take a form of First Person game. Coventry University Students' Optimisation and Management of Energy Resources (CUSTOMER) project is an example of First Person game with a focus on reducing energy usage within students' accommodations across the university campus (Pisithpunth et al. 2011). The CUSTOMER game project is currently being developed by researchers at Coventry University and this review is based on a prototype version.

CUSTOMER puts players in the role of students living in university accommodation. Layouts and furniture within the game bears similarities to a standard student's accommodation in the real-world. Electronic appliances present within the game are consistent with electronic

appliances commonly possessed by students (e.g. a laptop computer, music speakers, an electric kettle, and a mobile phone).

The goal in a CUSTOMER game project is for players to adjust and minimize their energy use without compromising their well-being. For examples, a computer laptop can be either turned on, off, or put on standby mode. Lights in a kitchen can be turned off when the facility is not in use and windows can be closed in order to minimize heat loss (alternatively, windows can be left partially opened in order to allow a limited-flow of fresh air into the room).

The game provides real-time feedback for players while playing the game including thermal comfort status, usage of electrical, gas, and water. Tips and instructions are available to players throughout the game.

In terms of initial evaluation, the game was presented to five Coventry University students in order to receive their feedback on software usability. A slightly modified version of QUIS (Questionnaire for User Interaction Satisfaction) developed by The University of Maryland Human-Computer Interaction Lab (n.d.) was used to gather feedback. Some participants were students with background experiences in computer games while others were students with experiences in computer programming. Data from participants were collected and processed with security priority. According to researchers, feedback from the initial evaluation has been favorable in terms of knowledge gains and software usability.

Interestingly, some commercial action games also combine environmental themes into their games. For example, I AM ALIVE (Ubisoft 2012) is a Third-Person action game with survival element that highlights the importance of resources management during the event of a disaster. The game depicts scenarios of a collapsed society after a catastrophic earthquake known as 'The Event'. Standard consumables such as bottled water, basic first-aid-kits, and canned foods are vital resources in this game. Many survivors have resorted to violence and other unlawful activities in order to acquire remaining resources.

Pollution plays an important role in I AM ALIVE. Dense smog from the collapsed buildings lingers at street level which drains a character's stamina over time as s/he traverses through these areas. The smog forces players to constantly seek out for high ground in order to rest or plan their next moves. Several resources and supply caches can be found in these hazardous areas, but players must proceed with extreme caution (as the character will die from running out of stamina).

Resources in the game are very limited in quantity. Thus, tactics such as resources conservation and careful exploration are of high importance in this game. Apart from pollution and disasters,

the game also highlights social disturbances that result from collapsed civilizations such as banditry, slavery, forced-prostitution, and cannibalism.

FALLOUT 3: NEW VEGAS (Bethesda Softworks 2012) is another commercial-entertainment FPS/TPS (Third Person Shooting) game with an environmental hazard and survival theme. This game has a background story of the world that has been transformed by the nuclear war. Centuries have passed since the massive detonation of nuclear warheads, but lethal doses of radiation still linger in the environment. Regions around the world have been reduced into irradiated and inhospitable wastelands. Remnants of humans on the surface struggle to exist within harsh environment and lawless civilization.

Equipment and supplies are essential for the survival of player's character. The main theme of this game portrays a scenario where humans have reverted from a consumerist to survivalist culture. For example, in an abandoned house players might find several canned foods and beer bottles from the pre-nuclear war era. Consumable are hard to come by and survivors have adapted to sustain themselves on insects, lizards, and other irradiated foods. A number of characters in FALLOUT are living in impoverish, unsecured, and insanitary conditions. Further, a number of characters in the game also regard others (including player character) with mistrust and disdain.

In standard game mode, foods and water are not required for survival (they are used to heal injuries instead). However, the 'hard-core mode' exists. When enabled, this game mode requires players to eat, drink, and rest in order to maintain bodily functions. To do this, adequate consumption and rest become essential. Failure to maintain bodily functions can result in reduced performance and eventually death.

As a survival game, crafting (i.e. creating new items from raw materials) is an important part of FALLOUT 3: NEW VEGAS. For example, players can squeeze the fruits of desert plants into an empty bottle to provide a portable source of water. Radiation plays a significant role in this game and players must be careful to avoid radiation when travelling (by listening to the static on Geiger counters). Also, players must selectively choose items to eat as prolonged consumption of irradiated foods causes health problems (radiation sickness). However, radiation sickness can be cured with a relative ease in this game.

METRO 2033 (4A Games 2012) is another survival game depicting deteriorated living conditions of human civilization after a catastrophic nuclear war. The remaining human population is forced to live in underground rail networks in order to avoid high radiation levels on the surface. During the course of the game, groups of scavengers (and players) need to travel through the surface level. However, the group needs to wear gas masks to protect themselves

from irradiated and toxic pollutants. Gas masks can be damaged during combats. Further, players are required to replace filters occasionally to ensure maximum protection. Failure to maintain these conditions will result in game over. Personal equipment such as flashlight and night vision goggles requires electricity, which, can be generated using a hand-crank dynamo (players need to left-mouse click repeatedly to perform this action).

Yet another survival first-person-shooting game with an environmental theme is MISERY, a modification (mod) version of S.T.A.L.K.E.R.: CALL OF PRIPYAT (GSG Game World 2012). The game is set in an alternate reality after the explosion of Chernobyl nuclear power station. To complete missions, the player must traverse from one area to another, avoiding environmental hazards such as toxic chemical and radiation hotspots along the way. Prolonged exposures to harmful elements will damage a player character's health severely. The negative effects of toxic pollutants and radiation can be countered by medications (a very expensive option).

Players also need to consume foods in order to maintain bodily function. These can be categorized into 'local' and 'imported foods'. Local foods can be gathered by hunting irradiated animals scattered within the game world. Meats obtained this way are generally lower in cost when compared to 'imported foods'. However, they contain a relatively high radiation level and can cause radiation poisoning. 'Imported foods', on the other hand, are far more expensive, but are radiation-free.

Environmental games can also take the form of traditional paperboard games. GREENPEACE's DEEP SEA DESPERATION (GREENPEACE 2010) is a two-player game addressing environmental problems caused by oil drilling operations. In this game, the first player takes the role of a Greenpeace operative while the second player takes the role of the Oil Company.

Each faction comes with its own special abilities. For example, Greenpeace can occupy Oil Company's tanker (cause score penalty to an Oil Company) and establish marine reserves (prevent Oil Company from drilling). The Oil Company, on the other hand, can drill the seabed for oil (generate scores) and lobby for the removal of marine reserves (i.e. undo Greenpeace's action). The win condition for Greenpeace is to establish marine reserves in all 'deep-water regions', while the win-condition for an Oil Company is to reach certain amount of scores.

Apart from an ability to choose between two factions, wildlife is an important factor in this game. There are five wildlife species: whale, dolphin, seal, polar bear, and panda. Wildlife species are represented by 'wildlife tokens' randomly scattered around the board. The panda has only one wildlife token while the other four have two tokens for each species (presumably to reflect an endangered status of panda species (IUCN 2012)).

Both factions compete against each other to win the game. However, both parties must avoid the extinction of a wildlife species. Extinction of any wildlife species will cause both players to lose the game. Extinction can occur by 'Blowout' (the result of Oil Company's roll that produces an identical value from two dices in a turn). Blowout causes an environmental impact (oil spillage) to cells within the board. Wildlife tokens are removed if they are presented within the affected cells. Both players lose the game if two tokens from a single species are removed from the paperboard. For example, both players will lose the game if two dolphin tokens are removed from the paperboard. On the other hand, both players will lose the game if a panda token is removed from the paperboard (since there's only one panda token in the game).

The narrative and artwork in DEEP SEA DESPERATION expresses the game developers' attitude to the oil Industry. The narrative tells the story of an oil Company which ventures into deep sea regions in order to open up new oil deposits to satisfy global oil demands. On the other hand, Greenpeace is portrayed as the ocean's protector. The game logo reflects an image of the ocean being covered by an oil slick. In the game, the Greenpeace token is represented by a-single seat speed boat while the Oil Company token is represented by a giant tanker (presumably to depict a small but agile Greenpeace operatives versus the powerful Oil Industries). The Oil Tycoon is depicted in a rather negative manner. The artworks also depict animals in desperate conditions.

ENVIROPOLY is another board game designed to address multiple environmental issues (Arslan et al. 2011). Game components include: tokens (representing players), a dice, and cards. Cards can be categorized further into chance cards, question cards, and reading cards. The board has a total of 42 cells. Each cell contains an instruction about daily life behaviours which can be positive or negative environmental practices. The game can be played by 5-6 players. Alternatively, a greater number of players can be grouped into 4-5 teams with each team directing a token.

The players progress through the game by rolling a dice. If a token lands on a question card, the player selects a question card from the deck and gives it to another player (B) without looking at the card. Player 'B' reveals a card and asks player 'A' the question. A correct answer allows player 'A' to move a token forward while the wrong answer will result in a token being moved backward.

Players will be penalized for landing into a cell representing environmental impact. However, a player can select a chance card. If the selected chance card has 'PASS' written on it then player will be exempted from all punishment on that turn.

Researchers (Arslan et al. 2011) have evaluated the outcome and effectiveness of the game on 44 undergraduate-level pre-service teachers. Participants consisted mainly of females and each game session took about 30-45 minutes. The outcome was positive, with observations and interviews suggesting that participants enjoyed the session as well as successfully learning new environmental topics. Interestingly, it was reported that one of the participants' suggestions to the researchers was for them to simplify the game narrative to help young school children to understand.

Perhaps one of the most classic and well-known environmental games is FISHBANKS developed by Dennis L. Meadows and his team in 1992 (Fish Banks, Ltd. : game kit n.d.). The game has been particularly utilized within education sectors (Ruiz-Pérez et al. 2011). The game was designed to be played by a small group of players in a competition against others. According to a source, a game session usually takes about two hours to complete, but can be split into two days (FishBanksGame.com 2012). Another experimental session has reported 45-50 minutes spent on a session (Ruiz-Pérez et al. 2011).

The setting of the game is an ocean divided into three areas based on their depths. These being: 'the deep sea', 'the coastal area', and 'the harbor area'. The deep sea area has a large fish stock, it has high fishing effectiveness but the operational costs are also relatively high (possibly representing an increase in crew payment and fuel costs). Coastal areas, on the other hand, have only half the amount of fish stock, a moderate fishing effectiveness, and operational costs. Lastly, the harbor area serves as a resting point for ships. Minimum upkeep cost is incurred upon ships resting at the harbor.

The weather plays an important role in FISHBANK. Weather is a random factor and can manipulate fishing efficiencies (thus, introduce uncertainty and dynamic during game element). Fish stock regenerates slowly overtime after being harvested. Players can purchase additional fishing boats to increase fishing speed. Boats are subjected to maintenance cost thus large fishing fleets are subjected to higher maintenance cost when compared to smaller fleets. The revenue gained by players is deposited in the bank. Positive bank accounts players with additional interest while negative bank accounts impact on players' interests.

At the end of game session, total assets assessed. The player with the greatest assets wins the game, this include the total deposits in the bank account as well as income after salvage of all ships.

Interestingly, Ruiz-Pérez et al. (2011) has reported from one of their game sessions that players rushed to maximize their gains toward the end of the session in order to win the game session. The result being a near-depletion of the fish population and destruction of the game's core

concept of sustainability (Ruiz-Pérez et al. 2011). In one of their studies, researchers used custom game rules to establish fishing regulations. The outcome suggested that regulation can help reduce the impacts and pressures of fishing on the environment.

Another classic environmental game is TRAGEDY OF THE GROUND WATER COMMON, a turn-based game developed by IGRAC (International Groundwater Resources Assessment Centre n.d.) The game is based on 'The Tragedy of the Commons' theory originally proposed by Garrett Hardin (Hardin 1968). The game mechanism has been described extensively by researchers van Weert and van Duinen (2010). According to researchers, the game is designed to be played by a group of 10 players. Nine players play as agricultural-based countries with their economies highly dependent on ground water networks. The last player plays a country dependent on aquaculture production which, in turn, depends on a ground water network.

All players must satisfy their countries' agricultural demands. Players pay pumping cost in exchange for water. Players can also expand agricultural areas in order to increase productivity. Fishing, on the other hand, is only possible as long as the groundwater is maintained above a certain threshold. All players suffer a penalty if no fish is produced in a round as their economies are partially dependent on fishing.

The game features the use of technologies to minimize environmental impacts. Players can invest in water efficient technology so that the demand on groundwater can be decreased while optimal agricultural output is maintained at the same time. Players who invest in technology bear the cost while the benefit is shared with other players throughout the regions. The game also allows for implementation of a groundwater management rule where players who exceeded the 'groundwater usage agreement' are penalized. This implementation, however, is only possible if it is agreed by majority of players (i.e. agreed by at least six players).

TRAGEDY OF THE GROUND WATER COMMON has been used in a number of experimental sessions (van Weert and van Duinen 2010). Also, researchers claim that the game promotes participants' understanding through a 'learning by doing' approach.

The above examples have shown games highlighting environmental issues from both serious and commercial circles. Some traditional board games have been reported to promote environmental awareness in players. On the other hand, digital game technology has becomes a powerful way simulating a number of functions and variables simultaneously. Several of the digital games discussed have been reported to promote environmental awareness in players.

1.9.3 Games targeting social & health issues

Apart from games highlighting environmental issues, there are also games that have been utilized to address social well-being and health care issues as well. These games are reviewed because links can be made between environmental, social, and health issues.

ASPIS (Auditing the Sustainability of Public Spaces) is a serious game project developed to promote players' awareness of the public space topic (ASPIS 2012). The game is available for free online and can be played directly from standard web browsers. Players assume the role of a protagonist in a quest to renovate a local park. The park, in turn, must be renovated to meet the needs of locals (groups of people with different interests).

Quests (i.e. game objectives) in ASPIS follow the systematic principles of background research, opinion gatherings, and decision making. For example, one of the early quests involves players participating in park inspection in order to commence necessary repairs. In another quest player gather opinions from park users in order to come up with plans to maximize space usage of the park.

In ASPIS, players take notices of the surrounding environment. For example, players will have to consider aspects such as interests of different groups, environmental concerns, and safety protocols. However, players won't be able to satisfy all park users and some of their requests will need to be discarded due to safety and sustainability issues. Players' decisions will influence the final outcome of the game.

Quests in ASPIS can be played in a non-chronological manner. For example, players may start at the 1st quest then skip 2nd and 3rd quest in order to play the 4th quest.

ASPIS was conducted in experimental game sessions at Coventry University in 2012. In one study, a small group of five students with computer studies background (Master and PhD entry level and from 3 different cultural backgrounds) played the game for 40-45 minutes. Overall, the game was perceived as entertaining and encouraging by participants. Interestingly, the game was able to produce a considerable degree of debates and discussion among players after the game session.

Topics of discussion among players and a researcher consisted of: technical aspects of the game, usability, and comparison between the socio-political issues within the game to the real-life (personal observation 2012).

SQUIRE'S QUEST (Health Games Research 2012) is a fantasy-themed adventure game for health targeting young children. The game aims to encourage children to increase their fruit, juice, and vegetable (FJV) consumption. The game has a background story of player's kingdom

being attacked by enemy forces. The enemies are destroying the kingdom's crops and players (as knights) are tasked with defending the castle. In order to defend the castle, players must complete quests which involve consumption and making more FJV for the king and others. The game has virtual assistants to provide guidance to players throughout the game.

In a systematic study, a team of researchers use SQUIRE'S QUEST as an intervention game on 1,578 children (Baranowski et al. 2003). The study concluded that game intervention can be used to increase young children's consumption of FJV by 1.0 serving when compared to children who did not play the game. Researchers acknowledged that this volume is not enough to satisfy consumption of FJV guided by nutritionists. However, such evidence shows how games can be used for behavioural changes.

THIS WAR OF MINE (11 Bit Studios 2014) is a commercial side-scrolling action game about survivors' living condition during a collapsed and war-torn country. The game has highlighted a number of social problems such as armed conflict, social disturbances, morality, and living conditions in a resources deprived area.

At the start, the game randomly picks up characters from the pool of pre-defined characters. This is a small group of survivors that requires a players' guidance in order to survive. Each character comes with his / her special perk(s). For example, a character is able to cook food for the group (raising the group's morale) while another is efficient at bartering (purchase item from other survivor groups at discounted price). Each character also has his / her needs that, if cannot be satisfied for an extended period of time, may result in depression (e.g. a smoker is depended on cigarettes).

As with many survival games (see I AM ALIVE and FALLOUT: NEW VEGAS), vital resources such as foods and medication are scarce – forcing players to scavenge and manage resources carefully. Additionally, fuel is required for cooking and space heating (the latter is especially critical for survival during snow storms). Sickness and injuries will gradually reduce characters' overall performance to the point of death if left untreated.

Morality plays an important role in THIS WAR OF MINE. Each character has his / her view regarding of morality. Still, a number of characters will be depressed if an immoral act is committed by a member of their group (e.g. betrayal, abandon those in needs, and banditry).

Although some studies have claimed the effectiveness of games for behavioural changes in a systematic evaluation (e.g. Kato et al. 2008, Baranowski et al. 2003), the effectiveness of games for behavioural changes are largely unexplored – especially for commercial-entertainment games. However, online observations have indicated that some games targeting social and health issues are being discussed by players and game enthusiastic. Survival games, for example, are being

linked to survival strategies and zombie-theme games are being linked to disease prevention strategies in some cases.

Many environmental games are being promoted based on 'environmental-only context'. In other word, social, health, and economic benefits from environmental conservation are underrepresented (e.g. resources conflicts, social disturbances, food and water contamination, and reduction in utility costs offered by sustainable technologies). To this, this study aims to explore the possibility of incorporating these contexts into the environmental game in order to attract players to these points of interest.

1.10 Conclusion & Research questions

In this chapter we have reviewed a number of key environmental issues originated from the unsustainable use of natural resources. Combined with the rapid human population growth, environmental problems magnified and disturbed the natural habitats worldwide. The impacts also reflected back to the human habitats – threatening the societal and health well-being. Apart from utilizing innovative and sustainable technologies, it is equally important to equip the public with environmental knowledge so that the populace may realize both the benefits of the environmental conservation and the impacts from ecological degradation.

When used appropriately, the game technology appeared to be both educating and engaging for many people as pointed out in some studies. This highlights the plausibility of using games to supplement the traditional environmental teachings. Apart from the traditional 'textual and visual information', the 'interactive' part of games allows the players to learn through 'trial-and-error' while interacting with the game environment. Additionally, while many commercial games lacked in educational value, their innovative and engaging game designs can be utilized as valuable additions for the serious environmental game applications.

Three research questions served as the objectives of investigation for this study. The first and the second research question aim to investigate the educational and the motivational values of using a game to teach sustainable population size and environmental conservation. The third research question, on the other hand, can be considered as the ultimate goal for the environmental conservation learning as it investigates the participants' viewpoints and behavioural intentions towards the concepts of sustainable lifestyles and environmental conservation.

RQ1. Can a single-player digital game be an appropriate and attractive learning application for the players to gain insight about the relationship between the growing human population and the environmental issues?

As mentioned earlier, studies have highlighted the possibilities of utilizing games as a supplemental learning application. Already, a number of environmental games have been developed to address different types of environmental issues, but not the growing population issue and its impacts specifically. For this study, however, the researcher proposes to create a prototype digital environmental game with a special focus on the growing human population issue.

By based the environmental issues on the growing population issue, the researcher convinced that the game would be able to demonstrate other social and economic issues stemmed from the unsustainable population growth as well. Therefore, the game might be of interest to non-environmental group participants.

The participants will be recruited to play the game for evaluation purpose. Participants' environmental knowledge outcomes (appropriateness) and motivational outcomes (attractiveness) will be collected and analyzed systematically to determine the prototype game's educational and motivational values.

RQ2. How can we design environmental games for the players to gain insights about the relationship between the growing human population and the environmental issues via playing a game?

A number of frameworks have already been designed to guide the development of serious game and learning applications in general. Examples of these frameworks include: The Four Dimensional Framework (4DF) (de Freitas et al. 2010), The EMERGO Framework (Nadolski n.d.), The Adult learning theories (Knowles, Holton and Swanson 1998; Wlodkowski 1985), The Flow theory (Csikszentmihalyi 1992), and The ARCS model for motivational design (Keller 2010).

However, the researcher has noted that these above-mentioned guidelines / frameworks were designed to cover game-based learning and traditional learning theories in general and not to support the development of environmental games specifically. The researcher argues that while the environmental games shared some common elements to the commercial and serious game applications at the basal level, the design and development of serious environmental games should take further steps by interpret these game-based learning elements specifically in the environmental context to achieve the desirable learning outcomes.

Inspired by the learning, motivational, and game theories, The Guideline for Environmental Games (GEG) will be developed to highlight options that should be considered for the development of environmental games (Please see GEG chapter for the details).

Thus this research question is concerned with the educational value of the proposed guideline and the components within the game itself. In order to answer this research question, the game sessions (played by the participants) along with the participants' verbal statements will be recorded and analyzed to identify important game elements that could be used to promote the environmental learning.

RQ3. What are the obstacles preventing the players from adapting environmental knowledge obtained from the learning mediums into the real-life?

While knowledge gain is the key for learning applications in general, the ultimate goal for environmental learning applications is for the learners to utilize the knowledge into the real-world (e.g. committing to sustainable lifestyles). However, the researcher recognizes that gaps exist between the knowledge gained and the desired behaviours. One reason is that each individual processes a degree of acceptance or resistance towards environmental responsibilities (e.g. Center for Alternative Technology 2010).

To investigate participants' viewpoints / perceived behavioural intentions towards the concepts of environmental conservation, their statements derived during the interviews will be analyzed and presented to highlight their opinions on the environmental and socio-economic issues. For example, it was highlighted during the small-scale pilot test that participants were more likely to recall game items from 'technology' category than from other categories. This highlights the role that innovative sustainable technology could be used to attract the participants to learn about the environmental conservation. In another example, some participants have highlighted the lack of governmental supports as a factor affecting their commitments toward environmental-friendly practices – highlighting the gap between theoretical knowledge and the real-world obstacles.

The researcher proposes that the participants' discussion on environmental and socio-economic issues are crucial for the environmental games evaluation because: 1) participants' statements can identify important environmental and social issues that they are interested in, 2) participants' statements can help the researcher understand their resolutions for each environmental and social issue, 3) participants' statements can identify the reasons that preventing them from adopting pro-environmental lifestyles, and 4) participants' statements can be valuable for the design directions of environmental games in the future.

2. A Guideline for Environmental Games (GEG)

2.1 Introduction

This chapter discusses the features of a newly proposed Guideline for Environmental Games (GEG). GEG was inspired by existing learning theories, game theories, and the recent innovative designs from both the serious and the commercial game camps. Additionally, solutions to the shortcomings observed in a number of environmental games (discussed previously in the literature review chapter) are discussed in this chapter. The aim of GEG is to provide key points that should be considered in the development of environmental games specifically.

A number of games and learning frameworks have already been proposed to guide the development of game-based and traditional learning applications. Examples of these frameworks include The-Four-Dimensional-Framework (de Freitas et al. 2010), EMERGO (Nadolski n.d.), Adult learning theories (Knowles, Holton and Swanson 1998; Wlodkowski 1985), Flow theory (Csikszentmihalyi 1992), ARCS model for motivational design (Keller 2010), and the framework for the management of public health and social issue behaviours (Rothschild 1999). Additionally, GEG also considers the recommendations and findings from recent studies in educational games (e.g. Gee 2003, Dunwell et al. 2012, Mayer, 2012).

While appropriated for serious games in general, these aforementioned frameworks did not discuss the development of games for the environmental learning context specifically. GEG, on the other hand, has taken a closer look at a number of key game elements and their relations / potentials in the environmental learning context. For example: What are the possible benefits and implications of using goals in the environmental games?[1] What results could we expect from introducing the competitive elements into the environmental games? Why is it important to maintain scientific fidelity and neutrality throughout the design of environmental games? How can linking up the game scenarios with the real-world scenarios might enhance the players' learning outcomes? How can we highlight the benefits / implications of sustainable technologies and environmental responsibilities into the environmental games meaningfully? These statements demonstrated that the development of environmental games requires specific considerations. Therefore, these vital game elements and their possible interpretations in the environmental game context will be explored and discussed in this chapter.

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[1] As evidenced in the FISNBANK game, introducing a goal and / or a competition into the environmental games might result in an unexpected result contrary to the objectives of the natural conservation (please see the literature review chapter).

2.2 Applying GEG into the environmental game development

The aim of GEG is to highlight game components and strategies that should be considered for the development of environmental games. However, it is important to emphasize at this point that GEG is designed to be a flexible guideline rather than a 'rigid checklist'. Three main reasons are provided here: Firstly, this is because the features presented within this guideline can be applied to a variety of environmental learning contexts (e.g. energy, forest conservation, recycling, wildlife and forest management, resources management, pollution management, or environmental policies). Each context, in turn, may require different design approach.

Secondly, as shown in the literature review chapter, environmental games can take many genres (or categories). Real-Time-Strategy environmental games (RTS) such as ANNO 2070, for example, can be especially useful in highlighting regional-scale environmental issues. Action and first-person environmental games such as CUSTOMER and JOM KITAR SEMULAR (JOKS), on the other hand, can be useful in highlighting environmental issues from an individual or household-level. These games require different design approach which will be discussed in this chapter. Yet still, environmental games can come in a 'hybrid form' thanks to the advancement in game technology. These hybrid games may include the key features of multiple game genres in a single game package.

Thirdly, the complexity and choices in game design are largely depended on factors such as the development timeline, resources, and target groups. For these reasons, the researcher emphasizes that it would be considered unrealistic to apply an entire guideline on every scenario or to satisfy every type of target audience (e.g. Malone 1980: 9, 21, 71; Keller 2010: 56; Koster 2005: 104; Caine and Caine 1990: 66, 69; Shute and Ventura 2013: 18).

2.3 The shortcomings in some environmental games

As discussed in the literature review chapter, the researcher has recognized a number of shortcomings in the existing environmental games such as:

- The focus on environmental-only perspective (i.e. only present the game from the environmental conservation perspective without considering the social and economic factors).
- Appeared as propaganda-like (e.g. antagonistic attitudes towards the general consumers, business, and industries).
- Failing to address in detail about the economic and financial advantages from environmental conservation. Examples include: the increase in land-values, the boost in tourism and the local economy, the long-term economic advantage from forest / oceans product harvests, the economic

advantage from the production of organic products (which commands higher market values), and the reduction in government's spending on healthcare and waste management programs).

- Over-reliance on technology (i.e. 'tech-fix'). While innovative and sustainable technologies are undeniably useful, some environmental games have over-portrayed the technologies – giving misleading impressions that advanced technologies would be able to solve all the environmental issues in the near future. These games are failing to emphasize on the importance of societal-based environmental conservation (e.g. environmental education, governmental policies, and cooperation from the community).

- Over-simplification (the lack of scientific explanation, game dynamism, and variety).

- Failing to address / demonstrate the complex interrelationship between the ecological and social factors (e.g. resources depletion VS social disturbances / air pollution VS health problems).

2.4 GEG Overview

In order to motivate the players to use serious game applications, it is important that players must be convinced to perceive the benefits provided by serious game applications they are going to use (e.g. Mayer 2012). For example: using business and training games for the opportunities of career advancement, learning health games to maintain healthy bodily functions and improve quality of life, and learning energy conservation games in order to minimize utility expenses. This is crucial as the main goal of serious games is to 'teach' and, if possible, to 'alter' the learners' behaviours as oppose to the focus on the 'entertaining' part found in many commercial games.

Similarly, Keller (2010: 45) emphasizes that learning applications should "Meeting the goals of the learner to affect a positive attitude". The researcher concurs with these statements and emphasizes that environmental games too, should be able to 'motivate' players to learn by demonstrate to target audients that the knowledge gained from the environmental games can be applied into real-life for both personal and societal benefits.

The benefits are relatively clear in many other serious game applications. For example: to learn driving lessons, a teenager may want to first start by using a driving simulator as a cost-effective alternative to the human trainers (s/he can also repeat the scenario and learn from mistakes for indefinite amount of times without being exposed to the actual risk of accidents). Another student may want to try a mathematic game with a purpose to improve scores on his / her final exams. Similarly, adults may want to use training simulators in a hope to acquire new job-related skills (opportunity for career advancement).

For several reasons, environmental games are dissimilar from other serious games mentioned above. Firstly, environmental education is not the core school subject in many countries (Thailand included). This means young students may or may not be motivated to learn about the subject since it is not going to be assessed by the formal examination.

Secondly, environmental education, by its own, does not offer obvious skill sets necessary for career advancement like driving, language, and mathematic games mentioned earlier[2]. Thirdly, the ultimate goal for environmental games (as well as other environmental learning applications) is to equip the learners with informed knowledge and convince them to support the sustainable consumption practices presented in the learning medium into the real-world (e.g. Connecticut Environmental Literacy Plan 2010). This can be a challenging objective as it requires the players to process the knowledge, form rational decisions, and then act accordingly. Even though environmental games could inform the players about the immediate financial incentives that could be gained from resources conservation[3], other environmental conservation practices such as choosing sustainable products, reduce meat consumption[4], and maintaining optimal family size might be perceived as 'too demanding' for many individuals.

Other actions also require players to sacrifice their time, convenience, and even financial assets in order to minimize negative impacts on the natural environment. Many of these conservation practices cannot demonstrate immediate and direct benefits to players. For example, sorting rubbish for recycling can help improve efficiency of recycling operation in the country and reduce operational cost (i.e. taxpayers' money) at the same time. However, the benefit of saving taxpayers' money may not be obvious for an individual.

Further, because the recycle requires cooperation from members of the community, some may be skeptical about contributions from others (i.e. "Am I the only person doing this?") (Center for Alternative Technology 2010: 155-159). On the other hand, utilizing advanced technology such as installing a grease separation system is an example of environmental commitment that requires time, efforts, and resources while legislations in many countries provide no financial and / or other incentive to the investors / users of sustainable technologies.

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[2] Nevertheless, Coyle (2005: 57) suggested that environmental-based education (EBE) can be used to improve learners' overall academic capacity.

[3] For example, turning-off light bulbs when not in use to save energy cost and invest in water-efficient appliances to save water cost.

[4] E.g. Parkhurst (2010), Center for Alternative Technology (2010: 30)

To this end, the researcher proposes that the combination of interrelating factors such as health benefits, moral aspect, and social well-being should also be incorporated into the environmental games where financial incentives are limited or absent. Additionally, the aspects of education, marketing, and law (Rothschild 1999) could also be presented into the learning medium, especially where the prospect of voluntary cooperation might not achieve desirable outcomes. The researcher proposes that these strategies could be used as an alternative to the 'environmental-only' aspect described earlier. The researcher also argues that this approach might be considered as a more attractive alternative option for the non-environmental conscious audiences (e.g. Rose 2009, Ulicsak 2010: 46).

Nonetheless, the context presented in the game alone may not be sufficient to sustain players' attention and motivation. To this end, GEG has considered meaningful game mechanism that could be used to sustain players' engagement with the learning medium at the same time.

2.5 GEG Components

Figure 2.1: The components of GEG
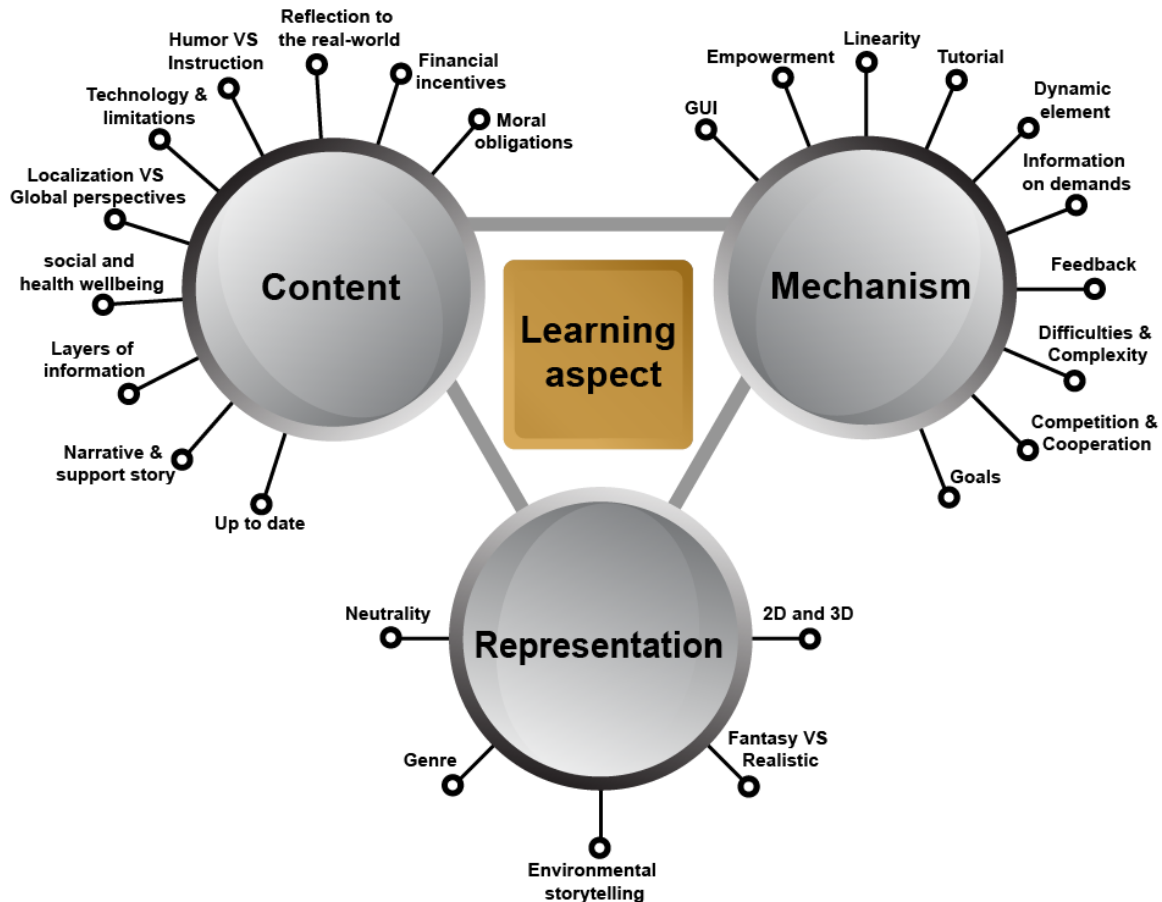
The figure above (figure 2.1) shows the three core 'game elements' of the GEG. These are the content, the representation, and the game mechanism respectively. Each core game element can be broken down into a number of sub-elements as shown in the figure. Each game element was inspired by the learning theories, game theories, and the recent developments in game technologies before repurposed specifically for the environmental learning context.

Finally, the core game elements are then aligned with the learning aspect to create an educative and engaging digital learning application.

Please note that some game elements can be overlapping depending on the interpretation, situations, and the strategies used. For example: the 'Neutrality' element (within the representation sphere) –

apart from being represented graphically[5] this element can also be presented textually via the game dialogues (therefore, also aligning itself with the content sphere). It can also be presented subtly through the use of game mechanism[6].

In another example, the 'financial incentives' element might be overlapping with 'Reflection to the real-world' element, and 'Technology & limitations' element (all from the content sphere) as the long-term financial incentives from the environmental conservation might be more effective when demonstrated using examples from the real-world (e.g. the recent development in integrated aquaculture technology leads to the reduction of water effluences, operational cost (water), and the increased in productivity at the same time). Further, we can see from this interaction that the assembly is also overlapping with the 'Empowerment' and the 'Dynamic' element (from the mechanism sphere) as well[7].

2.6 GEG: Content

Content is mainly referred to the textual information within games. Apart from graphical representation and mathematical formulae behind the game, most games are relied on textual information in some ways to send the message across to players. Textual information forms an important part of the game as Carr (2005) has expressed that: "Computer games are actualized through play: The user is a player, as well as a viewer, a reader, a consumer, and a spectator".

Embedded to the game mechanism, many games require the players to read and extract the information before they can proceed to the next level. For example: 1) choosing an appropriate dialogue option to respond to another player or an NPC (non-player characters) and 2) decipher a poem to solve the puzzles.

Textual information also being used to introduce players into the game world (e.g. storyline), explains game mechanism to players (e.g. tutorial), provides important information so that the

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[5] Please see DEEP SEA DESPERATION discussed in the literature review chapter as an example.

[6] For example, the process of deforestation portrayed in the game can be rapid and yield significant amount of one-time profits to reflect a short-term gain. The forest reclamation process, on the other hand, could be portrayed as a slow process with uncertain outcomes to reflect the process of natural reclamation and the political power undermining the natural conservation efforts in the real-world.

[7] As in many Role-Playing Games (RPG) where the player character(s) can be developed further during the course of the game, the financial incentives gained through the use of sustainable frameworks and advanced technologies can be demonstrated to the players using game mechanism (e.g. increased income rates to the players after applying a certain step) – therefore, the financial incentives element can be linked with the empowerment and the dynamic game element.

players can make informed-decision (e.g. textual / statistical reports on game status), and provide players with hints and additional information about game objects (e.g. feedback & inquiry-based system).

2.6.1 Narrative & support story

Beside the actual game design, many commercial games have already invested significant amount of efforts to develop storylines that used as a support element for the game (sometime referred to as 'lore' by some gaming communities).

NEVERWINTER NIGHTS (Bioware 2002), for example has a background story of a city being ravaged by a plague. The player's character is a survivor from the city's academy and is called to investigate the incident and save the city from the disaster. Although the game itself is focused on combats and adventures, game developers also provided the players with extensive storyline about the game world ranging from: geographical information, information on the inhabitants, technologies, flora and fauna, cultures, and politics. On another hand, MAX PAYNE (Remedy Entertainment 2012) is an action game that incorporated extensive storyline covering aspects such as a tragic family background, love, friendship, betrayal, humor-sarcasm, social issues, and other philosophical thoughts.

Apart from the 'lore' presented explicitly in the game, narratives can be presented in a subtle form. DEADSPACE 2, for example, is an action game focused on the players' attempt to survive from an alien outbreak occurred at a space installation. As players progress, they may encounter message logs (i.e. communication entries and diaries) left behind by deceased / escaped colonists. Some of these message logs highlighted issues such as the difficulties in coping with the stress of living in an artificial condition on a space installation, unethical covert scientific experiments, and governmental controversies. These message logs can be read while navigating within game environment[8]. This strategy can be useful in the environmental game context where the NPCs (Non-Player-Characters) may express the environmental issues affecting their lives to the players.

Apart from commercial games, narrative and stories are being incorporated into some serious games as well. Project ASPIS (ASPIS 2012) for example, provides background story about the main character named Peter trying to save the skateboard area in the park. The game also allows the player to communicate with other stakeholders (e.g. park users and city planners who have their own aims

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[8] Otherwise, the players may ignore most of these message logs without major impacts on the gameplay.

and agendas). Players can ask to hear the opinions of these stakeholders before renovating the park to the best interest of the community.

Another serious game incorporating storyline mechanism is SQUIRE'S QUEST (Health Games Research 2012) where the players assumes the role of a squire in a quest to help the country repel invaders' attack (by consuming more vegetable and fruit diet as the energy source).

Literatures and studies have highlighted positive outcomes from incorporating stories into games. Prensky (2007: 106) has suggested that stories can establish and deliver emotions to players, but also suggested that stories should not dictate an entire course of the game (Prensky 2007: 126-127). Hengeveld (2010) suggested that the combination of narrative and gameplay can enhance game experience. Similarly, Lombard and Ditton (1997) have highlighted the importance of storyline in both films and game media. Additionally, Gee (2003) has observed positive knowledge transfers in children using textual content-based game applications. However, Squire (n.d.) cautioned that in some cases, themes in games can generate negative influence on certain players (e.g. alienating the players of certain racial and cultural backgrounds).

To this end, the researcher proposes that the storyline should be considered for environmental games in order to promote level of engagement and positive learning outcomes. Moreover, the background story of the game could be set in an alternate-timeline of the Earth like FALLOUT (Bethesda Softworks 2012). It could be set on Earth, but predict forward into the future like ENERGYVILLE (Chevron-EnergyVille 2011). Also, it could be set in a fiction distance world that shares similar environmental situation to the Earth.

2.6.2 Reflecting game content to the real-world

Real-world scenarios are used in some serious game applications (e.g. Nadolski et al. 2008: 339). Real-world scenarios can be used to fortify the players' motivation (ibid.) In an agreement to a statement provided by Harteveld, Lukosch and Kortmann (2009): "… developers need to translate a part of reality into a game, while making sure that the game actually serves the purpose it is designed for", GEG purposes that environmental games should be able to reflect environmental problems described in the game to the real-world environmental problems to establish a connection between the game and the real-world in order to create an effective learning situation (e.g. Koster 2005: 52-53).

In learning theories, Wlodkowski (1985: 19) has highlighted that comparison, stories, and facts could be used to enhance the learning material and clarify the context. Marton and Booth (1997: 156) have

suggested that learning can be enhanced by making references to the reality. Similarly, Ambrose et al. (2010: 69, 83) has suggested that relevance can highlight the value of the learning medium and motivate the students to learn.

Thus, the goal of reflecting to the real-world is to create 'an information bridge' that allows the players to recognize the real-world environmental problems while engaging with the game activities. One simple strategy is to use the textual information. For example, in AGE OF EMPIRES III (Microsoft Studios 2011) players can select a game unit 'sheep' (a type of food resources in the game). The game then gives the real-world information about the sheep to players (e.g. biological description, human usages, and economic importance of the sheep).

For environmental games, the textual description of objects representing wildlife, forests, man-made devices and technologies, and pollutant could be given in order to inform the players of environmental situation in the real-world. For example, a game object 'forest' could contain general information about the remaining forest lands in the world. It could inform the players about the economic and ecological benefits provided by the forest. It could also inform players about recent threats to forests around the world (e.g. illegal logging, poaching, and encroachment).

Once the players have selected on a game object representing a tree, the game could inform players of the tree species that the game represented and then provides information[9] such as biological description, ecological and economic importance, conservation status, and the current threats to the species (if any).

The game could also informs the players of the 'good news' such as the successful raids on illegal logging operations, the recent governmental actions on forest protection, a series of boost in tourism and local economy attributed to the improved environmental standards, and the improving quality of life in the area as the result of positive environmental conditions. These 'good news' can be linked to the emotions of pride (for successful environmental conservation) and anger (toward environmental offenders) which, when triggered, can promote environmental conservation behaviours (see Harth, Leach and Kessler 2013). Further, the game may also highlight recent technological development that could be used to protect the forests. The aim is to reinforce to players that environmental protection efforts are being arranged by both the government and public sector, which helps counter the skepticism on environmental conservation efforts).

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[9] Similar mechanism was used in SIMCITY 4 where players can select 'sub-objects' within game objects. For example, selecting a factory in the game will give basic information (e.g. name of the factory, pollution generated, and land value). However, selecting sub-objects within this factory will give additional information (such as propane tanks, pine trees, and lamp posts located within the factory area).

2.6.3 Layers of information

Contents within the environmental games can be detailed, lengthy, and proves to be complex for the general audiences. Further, technical jargons can cause misunderstanding and alienation (Plain Language n.d.), deterring the players from using the game application.

For example, in-game description related to wind turbines can range from: 1) pollution generated during the construction of wind turbines, 2) unstable energy outputs due to meteorological factors, 3) maintenance and replacement issues, 4) types of wind turbines and their limitations, 5) energy storage technology, 6) interference with the radar system, 7) the impacts on wildlife (e.g. birds), and 8) socio-economic implications (e.g. public displeasure and effects on land values).

For this, the researcher proposes that content within environmental games could be broken down into smaller sections so that the players can digest the information comfortably. Hyperlinks can be used to explain the topic in detail.

The writing techniques such as 'The Inverted Pyramid' (Nordquist 2013) frequented by the journalists could be used to decompose the information into layers. For example, the first section might give a short summary about the wind turbines. The second section gives lists (e.g. bullet points) of main advantages and disadvantages of using wind turbines (e.g. clean energy, unstable energy output due to meteorological factors, high initial construction cost). The third section could include the full information about wind turbines. The fourth section, finally, gives 'trivial' information about wind turbines (e.g. turbines' blades can be dangerous to birds and the gearbox modules of wind turbines generally last about 10-15 years).

2.6.4 Inform the players of financial incentives

As mentioned earlier in this chapter, financial incentives can be incorporated into the environmental games in order to make the content more attractive to the non-environmental groups (e.g. Petkov et al. 2011). The purpose is to inform the players of actions that can be used to secure financial advantages while minimizing environmental pollution at the same time. Rose (2009) in another example, highlights that the reward system could be emphasized in order to attract non-environmental groups to join the cause. Similarly, Rothschild (1999) has suggested that a person is more likely to act if s/he can recognize the immediate benefits from it. Additionally, Knowles, Holton, and Swanson (1998: 67) have emphasized the importance of reinforcement factors that could be used to assist adult learners. This aspect of financial incentives can be an encouraging factor for adolescents and adults since some of the game information can be applied into the daily life and

result in immediate financial benefits (e.g. Knowles, Holton, and Swanson 1998: 149, Malone 1980: 3).

For example, the game could demonstrate the average financial loss in households caused by the phantom loads[10] in order to encourage the players to unplug electrical cables after each use (e.g. showing an average household loss while also comparing to the national loss). This way, the game could inform the players of financial incentive from reduced energy bills while help minimize environmental pollution (from electrical generation) at the same time. Similarly, the game could guide the players to the benefits of switching from the private to public transportation system such as: saving fuel cost, parking fee, and insurance fee, while avoid risks of vehicle thieves, traffic accidents, and mental stress caused by traffic congestion at the same time. Further, the information should be backed up by evidence from reliable sources.

2.6.5 Inform the players of social and well-being benefits

As mentioned earlier in this chapter, although some practices such as energy and water conservation can inform the players of the direct financial benefits, other practices require the players to sacrifice time, efforts and even financial assets in order to preserve the natural environment. In these cases, the direct personal benefits are absent – limiting self-interest for some participants (e.g. Onwezen, Antonides and Bartels 2013). To this end, the researcher proposes that social and health benefits could be promoted instead.

Dawes and Messick (2000) explained social dilemmas situations as: "… each individual always receives a higher payoff for defecting than for cooperating, but all are better off if all cooperate than if all defect". To this end, the game could, for example, demonstrate the benefits of recycling as well as highlight negative societal and environmental impacts should no one participates in the recycling activities (e.g. Rothschild 1999: 29). As mentioned earlier, the game could inform the players of the 'good news' about recent successes in carpool and recycling campaigns which allowed the community members to strengthen their bonds and reduce environmental problems in their community at the same time (e.g. Letscarpool 2013). As from the environmental viewpoint, the game could link air pollution to transport emissions in order to encourage the players to shift from private to public transportation system.

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[10] Phantom loading (or electric vampire) is the term for electrical appliances that continue to drain electrical energy even after being turned-off. This phenomenon can be prevented simply by unplug cables from electric sockets.

2.6.6 Incorporating moral and social obligations

Moral and social obligations could be incorporated into the environmental games. Due to their similarities, moral and social obligations might be included in conjunction with social and health well-being aspects discussed above.

Onwezen, Antonides and Bartels (2013) have highlighted that individuals are capable of perceiving experiences from the consequences of their future actions. In this context, the learning medium might describe to the players (in both textual and graphical format) about the worsening living conditions of those who are affected by the environmental pollutions caused by unsustainable consumption (e.g. pollution runoff from the undermanaged high-rise buildings into the impoverish areas).

Further, a study has suggested that immoral acts that players may have conducted during the game can elicit guilt emotion which may lead to increased social responsibility in the real-life (University at Buffalo News Center 2014). To this, games could be a suitable learning medium for evoking certain emotional outcomes by using the 'what if' scenarios.

In environmental games, this highlights the possibility of incorporating decision making scenarios into games. For example, a scenario may force the players to choose between the options of: A) supporting environmental conservation projects at the cost of higher upkeep versus B) supporting the unsustainable economic growth in exchange for substantial amount of financial resources, but at the cost of environmental degradation and risking the public welfare. If the latter choice was chosen, the feedback system such as the illness caused by pollution contamination should be expressed by the game[11]. This aspect of moral obligation can also be linked to 'Norm-Activation-Model' (NAM) (Schwartz 1997) where moral facet can play an important role in environmental decisions (e.g. Bamberg and Moser 2007, Onwezen, Antonides and Bartels 2013). Further, Harth, Leach and Kessler (2013) have suggested that the aspects of guilt, anger, and pride could be used to elicit environmental conservation behaviours (with each aspect triggers different emotional and behavioural outcomes).

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[11] In FATE OF THE DRAGON for example, the game sends a feedback: "Your generosity shines on your people like the sun" if the players decide to donate resources to help population being suffered from the impact of crop failure (with an image of a cheerful mother and her daughter in the background). Similarly, the citizens in ANNO 2070 are capable of producing multiple types of facial expressions based on their satisfaction with the city (e.g. the expression of hopelessness when being affected by disease outbreaks or delightful when their needs are met).

In game designs, moral and social obligations can be presented to the players by linking the real-world problems with moral concerns[12]. For example, environmental games could encourage the players to separate dangerous and toxic wastes from general municipal wastes in order to avoid causing accidental injuries to recycling workers as well as children living near the landfills. Moreover, garbage and pollution problems could be linked to health implication and deformities of the newborns. Chemical and Pollution runoff from households could be linked to the high death rates of sea turtles, dugongs, and other animal species. Food wastes could be linked to unnecessary loss of animal lives, exploitation of the poor in developing countries (e.g. the unfair trade), and the high level of malnutrition and starvation worldwide (e.g. World Food Programme 2014). At the same time, water conservation topic in environmental games could be linked to the high death rates worldwide caused by water contamination (e.g. The Water Project 2013) and the lack of access to clean water in some areas (e.g. Howstuffworks 2012).

2.6.7 Technology and its limitations

The researcher proposes that advantages of new technology should be included into the environmental games where possible and with caution. As mentioned earlier, innovative sustainable technologies could be linked to the concept of 'pride' as highlighted by Harth, Leach and Kessler (2013). Thus, the portrayal of new sustainable technologies in the environmental games might lead to a sense of pride and encourage the players to invest in these technologies.

Technology for environmental conservation can be put into several categories such as: 1) energy-saving technology, 2) water-efficient technology, 3) energy and resources recovery technology (e.g. heat recovery and anaerobic digester system), 4) pollution and waste management technology, 5) material technology, 6) food, energy, and resources storage technology, 7) sustainable designs (e.g. innovative product designs and construction frameworks), and 8) environmental protection technology (e.g. sensors). The goal of portraying technologies is to inform the players of long-term environmental and financial gains offered by new technologies.

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[12] Interestingly, mythical beliefs can also play an important role in environmental and social responsibility in some cultural scenarios. A 2014 report from Bangkok (Thailand) has suggested that using signs written with cursing statement - condemning environmental polluters to despairs while blessing pro-environmental behaviours with good fortunes can reduce garbage fouling in some sections of Bangkok's San-Saab river by 80-90%. According to the district manager, the warnings of financial penalty were issued in the past, but with little success (Thairath 2014c). However, the long-term effect from using this strategy is yet to be determined and GEG recognizes that referencing to mythical and religious beliefs to discourage environmental pollution must be utilized with caution to avoid alienation and rejection from the outside group who do not share similar beliefs.

Technology presented within the environmental games can range from simple and inexpensive inventions for household usage to large and sophisticated systems for commercial and industrial sectors.

For example, the game could inform players of the financial and environmental benefits from utilizing basic household devices (e.g. solar cookers and water leakage sensor). Backing up by the reliable sources, the game could compare energy consumption rate / cost between traditional light bulbs with new energy saving light sources (e.g. LEDs) in order to encourage the players to replace old light bulbs with energy-efficient ones. Apart from the energy topic, the game could inform the players that they could save water bills in the long run simply by invest in the rainwater collectors and water-efficient applications (e.g. toilets and washing machines). For the larger sustainable technology projects, the game could inform the players of recent development in solar and wind technology which has become progressively cost-effective and more efficient[13] (e.g. inhabitat 2014, SEIA 2014).

However, in consistent with GEG's 'Up to date' aspect (see below), the current shortcomings and limitations of the technology must be addressed in the game as well. These can range from the pollution generated during the construction and installation of the said technology[14], the risk of malfunction and stability issues (e.g. corrosive activity that could damage the Anaerobic Digester system and technical issues that limit the use of molten-salt energy storage system), inconsistencies (in case of solar and wind energy generation system), the high capital cost, maintenance cost, reliability, and durability (i.e. estimated service life-time).

For example, the game should inform the players about the amount of pollution generated during the production, transportation, and installation of wind turbines and solar panels. Technical limitations of these renewable energy sources such as inability to produce energy during violent wind speed, low wind speed, and cloudy sky should also be communicated to the players (e.g. Prodromidis and Coutelieris 2011).

Further, the game should discuss other support infrastructures such as the energy storage system so that the excessive energy obtained from renewable sources might be stored to be used later during the

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[13] E.g. airborne wind turbines and wave-to-energy system

[14] For example: the production of solar panels requires raw materials. Some of the raw materials need to be extracted from the natural source with consume energy and generate pollution. These panels then need to be assembled, transported and installed on target structures – contributing to environmental emission. Also, large solar installation requires constant diagnostic and maintenance. Eventually the panels need to be disposed if damaged or upon reaching their service-lifetime. All of these factors contribute to pollution problems.

peak-hours (e.g. flywheels (Liu and Jiang 2007), gravity energy storage (ARES 2013) and pressurized air energy storage (Cleantechnica 2013)).

Additionally, the game should highlight 'technologies for behavioural changes and awareness'. Examples include the sensors and real-time metering system, which simply remind the users of their consumption. This paradigm reinforces the importance of technologies that affect the users psychologically and call for their participation (e.g. CBEI 2013) rather than the sole reliance on technologies that tackle environmental problems directly.

2.6.8 Localization VS Global perspectives

The researcher proposes that it is necessary to address local environmental and social issues to the players in order to establish a sense of approximation (e.g. Rose 2009). For example, if the game is targeting players in country 'A' then a considerable amount of the content should reflect the environmental, social, and cultural value of people in that country. However, issues from the global perspectives should not be neglected as evidence have demonstrated that environmental and social problems can spread from one region to others (Thairath 2012a, Inhabitat 2014).

For example: by citing reliable sources, the game could reveal the recent statistical reports about the total registered private vehicles and the increasing air pollution in country 'A'. This statistic then can be compared to the data set from neighboring countries and to the rest of the world. To this end, the players would be able to compare the performance of their countries to the others. Additionally, using the models / policies from the developed countries might raise the players' awareness and ultimately, lead to some behavioural changes that would benefit both the society and the environment (e.g. Jensen and Oster 2009).

2.6.9 Up to date

A certain portion of the real-world information is presented in the game environment (e.g. Cohen, Manion, and Morrison 2007: 455). Thus, it is important that the information presented in the game must be up to date in order to optimize the learning outcomes and avoid the possibility of rejections from the learners. Therefore, the recent environmental situations such as the remaining forest lands, the global population size, energy, water, and resources consumption rate, wildlife extinction rate, and pollution level should be up to date.

Recent events in social and health contexts should be presented into the game. Examples include amplifying poverty and malnutrition rate, recent reports of environmental crimes, and increasing

number of patients affected by respiratory diseases caused by rising air pollution level. Additionally, the game could highlight the recent developments in sustainable technology which could be used to benefit the environmental conservation efforts.

Apart from updates on textual content, game mechanics too, should be updated so that the players could acquire the new knowledge while interacting with the game system[15] (please see the 'game mechanism' and 'experiential learning' section).

2.6.10 Humor VS Instruction

Humors have been an important aspect in many games and other media platforms. For example: TROPICO (Kalypso 2012) is a real-time city management game series which embraces the aspect of humor into their products. In this game, humors are mostly presented in the simple form of textual description for game objects. For example: an in-game description about a lumber mill in TROPICO 3 reads: "Find a heavily forested area and boost your early economy with this useful building. Cutting trees will outrage Environmentalists and Eco-tourists alike" (Steam 2012). Another example of games using humor is STRONGHOLD: CRUSADER (Firefly Studios 2012), a real-time castle management game which expresses the humor through players' interaction with townspeople. For example, townspeople may express that their "… trousers are slipping …" in response to the players' half-ration food policy.

Dormann and Biddle (2009) have highlighted the positive benefits of using humors in games. These include: promoting engagement, help sustain game activities, and produce a conductive learning environment. Similarly, Lombardi (2012) has suggested that humors could be incorporated into the games to increase the efficiency of language games. However, Lombardi (2012), Whitton (2010) and Keller (2010: 47) have emphasized that humors should be used cautiously and strategically in order to avoid distracting the learners from the learning context or unintentionally producing other negative outcomes[16].

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[15] The wind energy in SIMCITY 2013 is depicted as a somewhat low-operational cost energy generation system. This is in line with the current competitive energy price as the result from advancement in renewable energy technology.

[16] For example, some players groups may find a remark in one of TROPICO 3's in-game descriptions about a 'premium restaurant' to be offensive against the lower-income populace as it reads: "… exquisite cuisine rather than the suspicious looking foodstuff that the poor so readily ingest".

2.7 GEG: Representation

Graphical design is arguably one of the most important elements in the games. Graphical design not only gives the players with visual rewards, but also conveys powerful messages to the players when use strategically. Graphical representation discussed in this section includes camera perspective (which also defines game genre), the concept of fantasy VS the realistic approaches, environmental storytelling, and the choice between 2D and 3D graphical representation.

2.7.1 Genre

As mentioned earlier, environmental games come in different genres or types. For example, ENVIROPOLY (Arslan et al. 2011) and DEEP SEA DESPERATION (GREENPEACE 2010) are turn-based paperboard environmental games that can be readily setup and played by a group of players without the requirement of electricity or computer devices.

Several digital environmental games, on the other hand, are based on real-time city management genre. Examples include SIMCITY (Electronic Arts n.d.), ANNO 2070 (Ubisoft 2011), PLAN IT GREEN (Nat Geo Games 2012) and ENERCITY (Enercities 2012). Other digital environmental games such as FATE OF THE WORLD (Red Redemption 2011) are taking turned-based approach similar to paperboard games while JOM KITAR SEMULAR (JOKS) (Diah et al. 2012) and Project ASPIS (ASPIS 2012) are using adventure game approach.

However, as digital gaming technology has become progressively complex, many games are not restricted themselves to one of the 'arch-type' genres mentioned above. One of the early examples is DUNGEON KEEPER 2 (GOG 2013). This real-time strategy (RTS) game also allows the players to take a direct control of a game unit – temporality switching the game into a first-person genre. Further, the game also incorporated characters development system usually found in role-playing games (RPG).

GEG recognizes that each game genre has its own advantages for certain situations. Paperboard games can be useful in traditional classroom-based setting where participants can interact with game activities and other participants physically without the requirement of computer devices (e.g. Arslan et al. 2011; Arnab et al. 2012). Furthermore, emotions and body language can be expressed and shared among the participants during the gameplay which might contribute to the higher level of engagement / learning outcomes.

Digital games, on the other hand, while lack the face-to-face interaction can still simulate hundreds (if not thousands) of game variables at once and automatically. Unlike traditional paperboard games, rules and restrictions are controlled by the computer. This eliminates the need for the players to remember or enforce the game rules manually during the course of the game. For this, the constant flows in gaming activity can be maintained while players' cognitive power can be allocated to other important learning activities.

Real-time strategy games (RTS) and construction and management games (CMG), for example, are often used to present environmental issues at broader perspectives (although it can be used to present the context at household or local level as well). For example, in ANNO 2070 the players can carefully micro-manage individual game objects (e.g. a building) as well as issue key commands that would affect the entire region (i.e. the entire game map). The game can also highlight both local and regional problems (e.g. the disease contamination that affect few buildings in the area or high pollution level that implicates agricultural outputs in an entire region).

On the other hand, by exploring the game through the lens of the characters, First-person (FPS) and adventure games can be useful for highlighting the details of the environmental problems at individual, household, or community-level (please see I AM ALIVE and CUSTOMER PROJECT in the literature review chapter).

Role-playing games (RPG), by far, can be used to emphasize the interactions between game characters (e.g. choosing an appropriate response). Additionally, RPG can be used to emphasize the sense of progression (e.g. purchasing a hand-crank flashlight so the player character can explore the game world without having to rely on batteries). Furthermore, the emerging survival theme frequented by many recent RPG games might be adapted for the environmental games to emphasize on the importance of environmental hazards and resources management.

2.7.2 Environmental storytelling

In addition to the text-based storytelling, visual clues too, can be embedded into the game world to deliver powerful messages to the players (e.g. de Freitas and Jarvis 2006). This approach can also be useful in engaging players with the game as suggested by the studies (Hengeveld 2010, Carson 2000).

Similar to the textual narrative / storytelling, environmental storytelling in many games have been presented in subtle forms. Hidden message can be explored (or ignored) by the players – with or without the consequences on the gameplay. In this case, knowledge gains appeared to be relied on the 'accidental learning' (see Edwards (2009)).

In its simple form, environmental storytelling can be expressed visually. For example, litters and graffiti in DEAD SPACE 2 give clues about insecurity and negative opinions on the government. The environmental design of the game's scenes gives impression about the compressed living condition in a space installation. In another level of the game, a backdrop of hills and trees was painted on the walls in the children's playroom to imitate the earth-like environment, resonates the sense of illusion / deception.

In the environmental games context, visual designs can be used to highlight man-made pollution and environmental degradation. For example: chimneys, chemical tanks, networked pipes, and cranes can be used to represent industrial complexes. Radio towers, street furniture, skyscrapers, and building complexes can be used to represent human habitats. The water color, particle effects (e.g. smog) and stain texture on buildings can be used to signify level of pollution and environmental contamination.

At the same time, sharp contrasts between highly decorated skyscrapers against small impoverished buildings can be used to emphasize the notion of social gaps in the region. Further, fortified walls and warning signs on buildings can be used to reinforce the concept of crime and social vulnerability.

On the other hand: trees, hilly slopes, ocean and wildlife can represent natural habitats (although this is not always the case since natural habitats can range from forest lands to barren & desert-like ecosystems, rocky cliffs, and volcanic mountains).

Sound can also be used to alert the players to points of interest: For example, static noise (e.g. Geiger counter) can be used to signify the level of radiation contamination in the area. The sound of car

horns, engines, and construction can signify pollution and human activities. Also, the sudden change of game music can signify the change in gameplay[17].

Environmental storytelling can also be expressed via the game mechanism itself. For example, in Warcraft III (Blizzard Entertainment 2011), the fictional 'Moon Elves' is the only faction in the game capable of harvesting lumbers (a type of resources) from the trees continuously and sustainably without having to destroy the forest lands like other factions. However, the harvest process is much slower when compared to other factions. This can be considered as an environmental storytelling for two reasons. Firstly, the game mechanism portrays moon elves as a faction that lives in harmony with the natural environment. Secondly, the game demonstrates the long-term, albeit slow economic gains from the forest conservation in contrast to the fast, but short-term benefits from deforestation (although the relationship was demonstrated in a fictional capacity).

2.7.3 Fantasy VS Realistic

Fantasy can have different meanings depends on the context and interpretation. The degree of fantasy can also vary from one game to another. Literatures may refer to the concept of fantasy as the parallel / distance worlds that contain hypothetical theories and / or imaginary life forms (e.g. Mayes and Cotton 2001). On the other hand, fantasy might be referred to imaginary roles such as taking command of an army, driving racing cars, and piloting an aircraft (e.g. Sherry et al. 2006). Also, Malone (1980: 58) has categorized fantasy into extrinsic and intrinsic fantasy. According to (ibid), extrinsic fantasy can be described as: "the fantasy depends on the use of the skill but not vice versa" while intrinsic fantasy can be described as: "not only does the fantasy depend on the skill, but the skill also depends on the fantasy". Intrinsic fantasy is suggested to be superior than extrinsic fantasy in regards to engagement and instructional value (Malone 1980: 58, Malone and Lepper 1987).

At the same time, the players also have their own definitions of fantasy as one participant may refers to the concept of fantasy as: 'an otherworldly realm' while another participant may refers to the concept of fantasy as an opportunity to take different roles such as becoming a soldier and professional skateboarder (e.g. Sherry et al. 2006).

For example, STARCRAFT (Blizzard Entertainment 2012b) is a real-time strategy game set in the distant future. The game makes several references to Earth such as mentioning United States of America and Russia in the game story and having a faction called 'United Earth Directorate'. The

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[17] In AGE OF EMPIRE and RISE OF NATIONS (Big Huge Games 2013) for example, the soundtrack will be changed automatically during the combats.

game, however, portrays theoretical technologies such as cybernetic technology, advanced direct-energy weaponries, space colonies, and extraterrestrial species.

ENERGYVILLE (Chevron-EnergyVille 2011), on the other hand, is based on an unnamed city with a simplified landscape. However, this city shares similarity to the city of the real-world in term of events and technology. The game is capable of 'fast-forward' and suggests possibilities of the near future. Yet, these predictions are still within the scope of the real-world events. SQUIRE'S QUEST (Health Games Research 2012) on the other hand, is based on an imaginary realm which includes fictional characters such as mages, golems, and intelligent humanoid creatures.

Studies have offered opinions on incorporating fantasy elements into the games. A survey on young adults conducted by Sherry et al. (2006) has suggested that their focus group have expressed positive attitudes towards fantasy (for the fact that it allows them to take roles that considered impossible in the real-life). Kaplan, Akilli and Cagiltay (n.d.) have concluded from their experiment with adolescents that fantasy, along with other game factors can promote motivation. Malone (1980: 67) has emphasized that fantasy is an important element that can be linked to positive intrinsic motivation. (Malone and Lepper 1987: 231) have also suggested that games should consider incorporating multiple types of fantasy in order to attract broader groups of players (Malone 1980: 69). Cordova and Lepper (1996) suggested that the importance of fantasy aspect of the game may decline in older players. Nevertheless, Carr (2005) and Prensky (2007: 141-142) have suggested that preferences toward games can be changed over time. For example, Carr (2005) is contended from the experiment that female participants may adopt interests toward Fantasy Role-Playing Games (RPG) if given with an opportunity to see the gameplay or being introduced to the games by others.

In term of learning context, Cordova and Lepper (1996) have demonstrated from their experiments that fantasy and personalization can be incorporated into the learning materials in order to enhance motivation – at least for the young players. However, they also cautious that fantasy can be a distractive element for some groups such as the 'task-oriented' players (Cordova and Lepper 1996).

For GEG, the researcher proposes that the mix between the fantasy and realism should be considered for the development of environmental games[18]. The degree of fantasy, however, appears to be depended on factors such as target groups and the main objective(s) of the said environmental games. The 'what-if' scenarios normally exploited in games could be used to highlight points of interest to

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[18] The preliminary results from THE GROWTH (early prototype phase) have indicated that participants have enjoyed graphical representation of the game. With some participants commented that the prototype resembles the designs of other dystopian worlds found in games and movies.

the players. Game environment (i.e. setting & landscapes) could be altered to arouse and engage players with the game. Theoretical technology and policies could be cautiously introduced to highlight players to the alternative ideas for the environmental conservation.

2.7.4 2D and 3D

Currently, many commercial games are being presented using three-dimensional graphical representation technology (i.e. 3D). Many game development tools (e.g. game engines) are being commercialized to assist game developers in the creation of 3D games. Examples of these game engines include UNITY 3D, CryEngine, SourceEngine, and UnrealEngine (Petridis et al. 2012). Some serious environmental games have utilized 3D graphical representation. Examples include Project ASPIS (ASPIS 2012) and CUSTOMER (Coventry University Students' Optimisation and Management of Energy Resources) (Pisithpunth et al. 2011).

Overall, high quality 3D games are capable of delivering highly realistic visual representation such as: 360-degree camera movements, realistic & dynamic lighting system, realistic / semi-realistic physical and animation systems, and the elaborated special effects.

However, 3D games (especially high-quality commercial games) also require either medium or high grade computer system to operate. The high cost and limited availability of these computer systems can also limit the distribution of 3D environmental games to the public (e.g. in school settings and in some developing countries). Further, high grade computer system demands higher electrical consumption which is somewhat against the merit of environmental conservation.

2D (and 2.5D[19]) games, on the other hand, are still being developed by both the serious and commercial game camps. Many 2D games require a considerably lower performance computers system to operate when compared to 3D games. This advantage suggests that 2D games can be operated on multiple game platforms (e.g. desktop, laptop, tablet computers, and mobile phone). This also suggests that 2D games are suitable for large-scale distribution to public settings such as schools and museums. Examples of serious 2D environmental games include PLAN IT GREEN (Nat Geo Games 2012) and ENERGYVILLE (Chevron-EnergyVille 2011).

A small preliminary survey regarding of preferences on graphical representation in games was conducted on behalf of THE GROWTH project in 2012. Participants with experiences in gaming

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[19] 2.5D games can be characterized as games that use sets of pre-rendered images to give an impression of three-dimensional objects and semi-realistic virtual environment. Examples of 2.5D commercial games include FATE OF THE DRAGON, SIMCITY 4, PLAN IT GREEN and AGE OF EMPIRE II.

were shown with the early game footage in both 3D and 2D formats. The results indicated that the majority of participants (N = 43/61; 70.49%) would prefer meaningful gameplay over realistic 3D graphical representation. Supporting reasons given by the participants include unavailability of high-quality computer system and uncomforting experience while navigating the 3D environment (confusing animation / camera movement). The result highlights the plausibility of utilizing 2D technology for environmental games. This result is partially supported by Prensky (2007: 137) who has suggested that veteran gamers might prefer a robust gameplay than advanced graphical representation.

2.7.5 Neutrality

The researcher proposes that the neutrality in the environmental games is an important aspect to attract non-environmental conscious players to use them. Similarly, Whitton (2010) highlights that players can have negative attitudes toward games that they perceived to be 'biased'. For example, forest protection efforts in environmental games could be addressed based on scientific drives and long-term economic interests instead of being advertised as an attempt to save the 'innocent' and 'beautiful' animals. Also, industries should be portrayed in a neutral light instead of the 'antagonists' (see DEEP SEA DESPERATION).

In concurrent with the 'scientific drives' approach, 'unconventional' environmental conservation policies could be introduced into the games. Examples include managed hunting programs (e.g. Lindsey, Roulet and Romanach 2007) and a controlled trade in animal carcasses. These concepts have been proposed, and with potential, to generate financial resources to fund the environmental protection projects. However, game mechanism should also be able to demonstrate the positive / negative consequences from utilizing these programs to the players as well (e.g. extra financial sources at the cost of strong opposition from pro-environmental groups, and the risks of corruption).

2.8 GEG: Mechanism

This section will discuss game mechanism that can be considered for environmental games. Game mechanism includes GUI design, feedback system, linearity, dynamisms, competitive and cooperative gameplay.

2.8.1 GUI

Oxford Dictionaries (2012) defines GUI or Graphical-User-Interface as: "A visual way of interacting with a computer using items such as windows, icons, and menus, used by most modern operating systems". Using GUIs, users can simply trigger sets of pre-defined computer scripts instead of typing the command line interface (e.g. Lee and Lee 2011).

GUI is an important aspect of the game. Superior GUI design allows the players to use the game application with relative ease. GUI is also an important part for representation of the game itself (de Freitas and Jarvis 2006).

The researcher proposes that the following checklist should be considered for GUI design in environmental games:

- Utilize high-resolution and clear graphical GUIs

- Refrain from using GUIs that are visually similar to others in order to avoid confusion

- GUIs should be large enough to facilitate the ease-of-use

- GUIs should be able to transform (e.g. resize / color change / animation) to signify their interactive functions and to distinguish themselves from other static game objects. For example: GUI may appear brighter when a mouse-pointer is hovering on)

- GUIs should be able to display basic information about itself to the players when requested (i.e. tooltips). For example: when hovering on a 'tree GUI' for few seconds, a dialogue box appears with the prints: "this GUI can be used to plant trees which will eventually grow into forests over the course of the game".

- Alternatively, hover the mouse pointer over a GUI followed by a keystroke could be used to bring up a dialogue box with detailed information about GUI

- Players should be able to hide / show and customize GUI layouts if desired

- Only the main GUIs should be presented on the screen at the time to avoid confusion. Additionally, expandable GUIs[20] might be considered (e.g. when the player selects on a 'tree GUI', this GUI expands into several GUIs – allowing players to choose from different tree species to plant)

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[20] In FALLOUT: NEW VEGAS, for example, tapping the middle mouse button will bring up a command wheel – a circular GUI menu divided into several sections. Each section is a GUI in its own right and can trigger different commands. In some games, game time will be slowed down or stopped automatically while a command wheel is being accessed by the player.

- In addition to the use of mouse-pointer, keyboard shortcuts should be used (e.g. press ESC key to return to the 'main menu' or press F1 key for help)
- The use of mouse-wheel should be put into consideration. This is because old computer mice (without wheels) are still in used in some locations (e.g. public libraries and schools)

2.8.2 Information on demands

Gee (2003) has highlighted that information system in computer games have some advantages over the traditional learning materials. Gee (2003) gives an example where the players can selectively view a specific set of 'useful' information that relevant to the current game stage. Alternatively, the information might be presented to the players automatically.

In I AM ALIVE, for example, several dialogue boxes will appear often during the early game chapters. These dialogue boxes inform the players on game controls and strategy. In one case, a dialogue box appears as the player character obtains his first weapon and explains that it can be used for self-defense or to force-open the locks.

Information on demand can also be combined with the Graphical-User-Interface (GUIs). In SIMCITY (Electronic Arts n.d.) for example, the players can view detailed information about special buildings that can be built. However, unavailable buildings will be presented in grey color to signify unavailability (due to insufficient funds or lacking prerequisite conditions).

In another example, an animated GUI appears at the corner of the screen in ANNO 2070 during the fire accident. Novice players can select on this GUI which will expand and give information about how to set up fire protection systems in the city. The GUI itself will disappear and the information moved into the game's archive system (i.e. library) which can be reviewed by the players later.

The researcher purposes that these GUI strategies could be used for the development of environmental games. Sets of useful information could be scripted to appear when they are likely to be needed by the players (e.g. warn players about the approaching environmental catastrophes and offer relevant suggestions on strategies that can be used to mitigate imminent environmental problems).

2.8.3 Linearity

Linearity can have multiple meanings in games. This context will refer to the degree of freedom that the players can exert within the game world. For example, missions in THE WITCHER (GOG 2012) involve forcing the players to make hard decisions (via the dialogue options). Each choice that the players have made earlier will result in different outcomes later in the game.

Similarly, environmental games may utilize the aspect of choices in a meaningful way. For example, the players might allow a group of poor families to settle next to the forest land in order to alleviate their suffering, but at the risk of environmental problems such as deforestation, illegal hunting, and environmental pollution.

Thus, non-linear games could be linked to 'Experiential Learning' and 'Inquiry-Based Learning' where decision-consequence mechanism is employed and the players are encouraged to explore different possibilities within the game environment (Mayo 2007)

In another example, linearity may refer to the 'opened-world' theme frequented by the gaming community. In this scenario, the players are allowed to act freely within the game world (while still bound by the game's rules). The main game objectives might be ignored or at least – prolonged. Examples of these games include GRAND THEFT AUTO (Rockstar Games 2012) and THE ELDER SCROLL (The Elder Scrolls 2014).

Furthermore, non-linear gameplay can also be linked to the randomly generated game contents by the system (e.g. random scenarios, random positive and negative reinforcements provided to players by the game). For example, ANNO 2070 (Ubisoft 2011) can generate a random map with unique geographical characteristics each time the players start a new game.

In some cases, non-linear games can also refer to a mechanism where the game can be restarted anew and the players can transfer in-game progress (e.g. status and inventory) that they have previously acquired from a game session into a new game session. This game mechanism is also referred to as 'new game plus' (NG+) by some gaming communities. Examples of games with this mechanism include DIABLO (Blizzard Entertainment 2012a) and DEADSPACE 2 (Electronic Art 2012).

On the other hand, some environmental games are objective-specific and linear in gameplay. The players take certain action(s) in order to fulfill game objectives. Once these objectives are fulfilled, the players will be presented with a conclusion statement (e.g. scoreboard and comparison to other players). Examples of these linear games include, JOM KITAR SEMULAR (JOKS) (Diah et al.

2012), HONOLOKO (European Environment Agency n.d.), and ENERGYVILLE (Chevron-EnergyVille 2011).

On the contrary, games such as SIMCITY (Electronic Arts n.d.) and ANNO 2070[21] (Ubisoft 2011) are non-linear 'sandbox' games[22] where the players can remain within the game environment indefinitely (in a persistence and self-contained game world).

Although the trend towards non-linear / open world game themes appear to be rising in the commercial entertainment game camp, they may not be suitable for some serious environmental games where the learning outcome is the core objective. Linear and structured games can be crucial for learning in certain situations as highlighted by Prensky (2007: 55). For examples, a construction simulation may require the players to take both chronological and logical steps to ensure health and safety of the building, workers, and the local populace. Similarly, an environmental disaster management simulation may require the players to prioritize their actions within a specific timeframe to minimize loss and other negative consequences (e.g. a forest fire management game).

The researcher proposes that environmental games should consider incorporating certain level of non-linearity into the game where possible. As mentioned earlier, this could be in the form of dynamic game system and storyline or utilize the opened-world mechanism. After all, environmental games could be centered on the continuous protection of the natural environment[23] while balancing social and economic prosperity at the same time.

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[21] The campaign mode of ANNO2070 can be considered as a linear gameplay because the game will transport the players to the new area (city) once the game objectives have been fulfilled (players can still choose not to complete these objectives in order to stay in the mission). However, players can build and nurture a city for indefinitely in the game's 'free-play' mode.

[22] Some gaming communities also referred to non-linear city building and management games as 'god games'.

[23] As mentioned earlier, in one of the experiments by Ruiz-Pérez et al. (2011), players have nearly exhausted natural resources in one of FISHBANK game session (a linear game). This is due to players' aim to maximize game score (financial capability) toward the end of the game session.

2.8.4 Goal

The goal is one of the most crucial elements for games Malone and Lepper (1987: 225) as in other learning context (see Ambrose et al. 2010: 70, 73). Malone and Lepper (1987: 231) and Bandura and Schunk (1981) have emphasized the importance of explicit goals in games and positive motivational effects on the learners (also see Csikszentmihalyi 1992: 209).

Goals can be categorized into proximal goals (Stock and Cervone 1990) and long-term goals. Proximal (or short-term goals) in games can be objectives that the players can accomplish within a relatively short time[24] or objectives perceived by the players as accomplishable. Long-term goal, on the other hand, can take from few hours to several days to weeks in order to complete (e.g. eliminate all major sources of environmental problems in the region).

Linking goals to the previously discussed aspect of linearity, some successful commercial games have granted the players with a great degree of freedom to interact with the game world. These games can be linked to what the gaming community has collectively termed as: 'Sandbox Games' and 'Open World Games'. GRAND THEFT AUTO and S.T.A.L.K.E.R.: CALL OF PRIPYAT are some examples for this game type where the players can interact with game objects in the dynamic game world freely – sometime diverging the players from the main objectives (goals).

Other commercial games, on the other hand, simply did not express their goal condition(s) to the players explicitly (e.g. SIMCITY 4). Djaouti, Alvarez and Jessel (n.d.) has referred to games without goals as 'Play-based' games. Apart from this, some games may allow the players to develop goal(s) of their own desires[25] (Squire 2011: 29).

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[24] 'Side quests' can be used as an example for proximal goals. During a session, the game may ask the players to assist in relocating a herd of rhinoceros to a natural reserve area. For a successful task, the players will receive scores and supports from environmental groups which also help them to achieve long-term goal(s). In another example, players in ASPIS (please see the literature review chapter) will have to complete multiple short objectives presented in a level such as: talking to stakeholders, conducting landscape surveys by taking photos, and distributing flyers. Each of these objectives, in turn, contributes to the final goal of the game. Another example of proximal goals can be seen in I AM ALIVE, where players' progress can only be saved upon reaching 'checkpoints'. Thus, reaching each of these checkpoints can be considered as fulfilling a short-term goal.

[25] Fable (Lionhead Studios 2004), for example, is an open-ended adventure game where, for many parts, allows the players to explore and travel within the game world freely. Players are allowed to develop their characters without restriction. Morality plays an important part of this game where the players can choose between the paths of 'good' or 'evil' through their interaction with other game characters – essentially shaping the course and even the final outcomes of the game.

Owning to the gaming community's welcoming reception toward 'Sandbox' and 'Open World ' games, environmental games too, could consider using both proximal and long-term goals in order to reach out to wider gaming groups. Where short term goals could be important for fostering the players' motivation and fulfilling certain learning objectives, the long term goals could also be suitable for the context of environmental game since the purpose of environmental conservation is the continuous nurture of the natural environment.

2.8.5 Dynamic game mechanism

The dynamic game mechanism in this context refers to the logical game mechanisms that can be adapted according to certain situations within the game world. Dynamic game functions are useful because it can enhance the interactivity of the game (e.g. Malone 1980: 52, Koster 2005: 38, 116) and provide the players with greater freedom of choices (Egenfeldt-Nielsen 2007).

In the context of environmental games, the dynamic gameplay can be a very important game element since they could be used to highlight the complex interrelationship between the natural environment and the socio-economic factors.

In the learning context, the dynamic game element can be linked to implicit learning (Claxton 1997: 22-23) and Inquiry-based learning (Mayo 2007) where the players must constantly evaluate their strategies and consider multiple avenues that can be used to achieve the goal(s). However, care must be taken into consideration when designing the dynamical game mechanism because it may also increase complexity and to some extends - difficulty of the game (Egenfeldt-Nielsen 2007). Further, the complexity of the dynamical game mechanism could lead to unexpected game behaviours in some cases – interfering with the intended learning objectives (e.g. computer bugs and exploitable software glitches).

A classic example of serious games incorporating dynamic game element is FISHBANK (FishBanksGame.com 2012) where overfishing by the players can result in declining fish population in the ocean. Fish population will continue to decline until collapsed if the players cannot reach a consensus to preserve the stock of wild fish. Random events such as season change also affect wild fish stock – adding new factors to the gameplay. In this case, the dynamic gameplay can facilitate the implicit learning aspect by highlight the short-term resources extraction and the long-term benefits from environmental conservation.

A number of commercial games discussed earlier also incorporated dynamic game mechanism. For example, resources-population relationship can be observed in FATE OF THE DRAGON (SQUARE

ENIX 2012) where the players in command of large armies are also required to manage and provide their troops with large amount of food supplies. Insufficient food supply can result in weakness and reduced morale. Large armies also require larger supplies of tree logs (for construction and food preparation). For this, rapid deforestation can be observed in long game sessions.

Another example can be found in SIMCITY (Electronic Arts n.d.) where larger population sizes also generate larger amount of garbage. Recycling stations can be built to accelerate the process of waste management in the city (albeit at an increased operational cost). Alternatively, the players can build garbage incinerators which help reduce garbage problems at accelerated speed while also generating electrical energy at the same time. However, the garbage incinerators also contribute to high amount of air pollution. Air pollution, in turn, causes sickness for the population – resulting in patients being admitted into hospitals. The players then will be required to build more hospitals to support the increasing number of patients. In turn, hospitals are relatively expensive in term of operational cost.

Similarly, high pollution levels in ANNO 2070 (Ubisoft 2011) causes a sharp reduction in agricultural outputs. If ignored, the pollution situation can escalate into the 'acid-rain' which causes severe and long-termed environmental impacts to the region. Apart from this, the game also highlighted possibilities of disasters. For example, areas far from a fire station are more likely to catch fire while areas far from police patrols are more likely to experience higher crime rate when compared to other areas.

2.8.6 Uncertainty & Surprises

Uncertainty & surprises can be incorporated into the environmental games to create a meaningful learning arena. In this context, uncertainty & surprises can be used to highlight unpredictable events such as the natural disasters (e.g. draughts, crop failures, and earthquakes), man-made disasters (e.g. industrial accidents), and social disturbances (e.g. wars, disease outbreak, and crimes).

It can also be used to highlight the 'good news' and the 'beneficial effects' that the society may receive from environmental conservation efforts. To create a meaningful learning activity, the players should be able to influence the occurrence of these random events to some extends while a reasonable / valid justification must also be considered. Consider the following sample scenario:

Poor environmental condition in the city could increase the occurrences of natural disasters. On the other hand, the players are more likely to receive 'Public supports' when the environmental conditions and the environmental awareness in the city is high. These public supports may range from pro-environmental activities such as reforestation, increased recycling rates, and increased donations

towards the environmental conservation projects. Further, the occurrences of positive socio-economic effects from environmental conservation such as increasing eco-tourism activities could also be highlighted in a similar manner.

Uncertainty & surprises can contribute to enjoyable experiences as suggested by Csikszentmihalyi (1992: 73). In the learning context, they can be used to promote players' attention (e.g. Keller 2010: 47) and learning engagement in adult learners (Howard-Jones and Demetriou 2008). However, Howard-Jones and Demetriou (2008) have suggested that the element of surprises associated with setbacks and loss can generate emotional impact on players although the effect did not appear to discourage them from the activity.

2.8.7 Tutorial

Tutorials have been long used as a manual / instruction in games. Tutorials introduce the players into the game's mechanism and narrative. For some games, the tutorials can be skipped. Other games, however, force the players to partake in the tutorial before they are allowed into the actual game levels.

In its simplest traditional form, a small book explaining basic game mechanism will be shipped with the game (although recent games are relying on electronic book formats such as using the PDF files). In its advanced form, however, the tutorials allow the players to practice within the game world, adjusting game parameters, and introduce the players to the core game functions and mechanism during early game levels. Guidance in the form of text-based, graphical, or voice-over narration might be provided once the players have reached certain stages (e.g. Gee 2003).

To this end, advanced tutorials can be linked to the 'experiential learning' approach (learning by doing). However, advanced tutorial can be much more expensive in term of development cost when compared to the traditional text-based tutorial format.

2.8.8 Feedback

Feedback is an important element for supporting the learning in general (Ambrose et al. 2010: 79). Feedback systems have been long used in computer games where the combination of textual information, visual feedback, audio, and statistics can be used to provide feedback for the players.

One of the key advantages for utilizing digital games in the learning context rests in its ability to provide the players with instantaneous feedback. This is different from the feedback systems usually found in traditional learning settings (e.g. classroom) where the feedback are normally provided to

the learners after a certain period of time, or at the end of the sessions (see Prensky 2007: 128). Instantaneous and meaningful feedback also helps the players to sustain concentration (e.g. Csikszentmihalyi 1992: 49) and reinforce their intrinsic motivation (e.g. Ryan, Mims and Koestner 1983). Keller (2010: 52) has suggested that the players' confidence may decrease as they have to wait until the end for feedback (e.g. in classroom-based tests). Edutopia (2010) has highlighted that games can administer the context and then provide constant streams of feedback for the players in meaningful ways.

As highlighted above, a meaningful feedback system helps promote the learning activity. To this end, examples of feedback in the digital games are:

- Numerical values / graphical GUI depicting the amount of damage being inflict on game objects (e.g. how many hours until the forest is destroyed by the toxic chemical runoff) (e.g. Prensky 2007: 121).
- Inform the players of the situation[26] (e.g. when the environmental condition in the city is reaching a critical level).
- Monitor the players' progress and automatically provide feedback when needed (Ulicsak 2010: 34). This can be linked to the 'Information on demand' aspect as discussed previously.
- Response to the players' immediate choice of actions (e.g. an NPC thanks the players for their helps on rescuing wildlife in the area from illegal hunters).
- Provide the players with a score sheet for performance evaluation (can also be compared with other players in case of competition-based games). Also, feedback can provide the players with current statistics (e.g. the time spent in the game world or the amount of in-game resources accumulated by the players).
- Provide clues for the players about the current objective
- Inform the players that they have been playing the game for extensive period of time and should take a rest (e.g. LINEAGE 2 and ANNO 2070).
- Response to the players whether they have answered the question correctly or not (such in quiz-based games) (e.g. Dempsey, Driscoll and Sales 1993).

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[26] In World in Conflict (Massive Entertainment 2007), for example, the game provides audio feedback "keep going, you are winning!" to the players when their scores are significantly higher than the enemy. By contrast, the phase "fight harder or you lose" is used when the players' scores are significantly lower than the enemy. This technique could be applied to environmental games by praising / remind the players of the surrounding environmental conditions.

- Provide attributional feedback such as "Well done!", "Not bad!" or "Try again!" (Ambrose et al. 2010: 79, Keller 2010: 52).

In the digital game platforms, the feedback system can be incorporated with GUIs which allows the players to attend to important issues with a relative ease. For example, SIMCITY 4 uses a GUI to alert the players about the fire disaster in the city, if this GUI is selected, it 'jumps' the players to the area being affected by the fire disaster immediately (i.e. without having to locate the area manually).

In another example, graphical feedback in ANNO 2070 informs the players on the efficiency of the shipping routes. A green 'thumb-up' icon informs the players that the current transport route has been setup efficiently while a red 'thumb-down' icon has an opposite meaning.

The researcher purposes that examples of feedback highlighted above should be considered for the development of environmental games. In this case, feedback could be considered as 'a helper' to guide new players as well as acting as reminders for experienced players.

2.8.9 Difficulties & Complexity

Challenge is one of the key elements that can be linked to intrinsic motivation (Ryan and Deci 2000, Malone and Lepper 1987: 231). The researcher proposes that environmental games should be complex and challenging enough to highlight environmental obstacles in the real-world (e.g. ecological, economical, societal, and political factors). However, like other games, environmental games should maintain the balance and refrain from instill the players with the sense of hopelessness to the point of impossible to accomplish the game tasks (e.g. Koster 2005: 44, Prensky 2007: 125, Csikszentmihalyi 1992: 49).

Malone (1980: 56) has suggested that level of difficulty should be adjustable to match with the players' ability. Indeed, the level of difficulties can be adjusted in many entertainment games – both manually and automatically (e.g. in action games where enemies are relatively weak and clumsy in the easy mode, but are intelligent and focused in the hard mode). However, the researcher proposes that the level of difficulties in the environmental games should be adjustable in meaningful fashions. This is to preserve the realism and the educational value of the environmental game. For example, players should neither be allowed to adjust the grow speed of trees nor turning-off disasters in the game as doing so would limit the learning part of the game.

Instead, environmental games should seek for the meaningful alternatives to lower the difficulty level for the entry-level players. For example, the game could allow the players to choose from different

scenarios (i.e. maps). The first scenario (i.e. the easiest level) could represent a land enriched with natural resources and is relatively safe from the seismic activities. On the other hand, the fourth scenario (e.g. the hardest level) could represent a land where natural resources are depleting, pollution level is high, civil disturbances are reaching a critical level, and the risk of natural disasters imminent.

Apart from this, there are other minor aspects associated to difficulty level of the game. Consider the following examples:

- Should the players' actions take immediate effects in the game? For example: when the players have issued a recycle campaign, should the game delay for a certain amount of time before applying the effect of environmental benefits to the game? For this, the purpose is to simulate the fact that the recycling campaign initiative must be reviewed by policy planners, arrange for budgets, and transmit the strategic plans to the community leaders among others.

- Similarly, when a player decides to construct a waste processing station, the game might take a delay to simulate construction process and recruitment / training of workers. Further, the termination of waste processing station should incur financial penalty to players to simulate the 'discharge pay' that the players must provide for dismissing the employees. This approach aims to reflect the real-world procedures and encourages the players to 'plan ahead'.

- Should the players perform the minor tasks manually or should the game simplify these tasks for them? In the post-apocalyptic world of METRO 2033 (4A Games 2012) for example, players have to 'click' the mouse repeatedly to simulate the use of hand-dynamo charger (generating electricity without reliance on the batteries). This aspect might be considered for the role-playing and action-type environmental games.

- Should environmental games keep rewarding the players for minor and trivial accomplishments? For example, give the players with in-game resources upon reaching a new level.

- Should the players be allowed to experience series of setbacks for inaction and failures? (e.g. Koster 2005: 122)

- Should environmental games incorporate the socio-economic factors? For example, should the game highlight health and security issues such as illnesses caused by the increasing pollution, crimes, anti-environmental movements, and economic depression? Also, should the game penalize the players for failing to maintain social well-being and reduce crime rates in the city? (E.g. take away some of players' resources due to lack of public supports on environmental campaigns).

- Should the game highlight the political intervention? For example, if the game put the players in the role of an environmental manager then should the game include a scenario where the industrial committees attempt to undo players' efforts? Should the game include a scenario where the forest protection units would clash with the local populace who wish to turn the forest into farmlands? Should the game include a scenario where foreign powers pressure the players to accept toxic wastes in exchange for financial and political supports?

These aspects should be considered for the design of the environmental games. However, it is important that the game must strike a balance by offering players with the 'taste' of pressures without de-motivate players by making the game's tasks seemingly impossible to accomplish (e.g. Gee 2004).

2.8.10 Empowerment

Shubik (2009) has highlighted that games contain both entertaining and instructional elements. Hansmann et al. (2005) has emphasized that the aspect of enjoyment should be incorporated into instructional games to motivate players.

Prensky (2007: 101) has suggested gratification and power, among other factors, as the motivational factors (although the literature discussed these motivating factors in the real-world context). Similarly, Hilgard's principles suggested that reinforcement is a crucial element and the learners should be rewarded for the correct actions / responses (Knowles, Holton and Swanson 1998: 74) whereas Koster (2005: 58) has discussed the aspect of power within games. Further, Squire (2011: 161) has noted that learning can be rewarding when skills exercised by the players can empower and help them achieved their goals.

Apart from the obvious correlation between the environmental degradation and human activities, GEG proposes that environmental games should also emphasize on the importance of interrelating topics that have stemmed from environmental degradation as well (e.g. social, economic, health, security, and political issues). These interrelating topics enrich the game (and increase its complexity) as players are required to manage multiple factors at the same time.

For this, the aspect of empowerment could be used in the environmental games to help the players progress and overcome sets of problems presented by the game. As earlier-mentioned, the concept of empowerment could be linked to 'technological improvements' and the emotion of 'pride'.

For example, the players could invest their resources into an environmental-friendly business. Profits gained from this venture then can be used to: 1) fund other investments to secure political and financial advantages, or 2) fund environmental-related projects to improve overall environmental conditions in the city. Apart from serving as 'proximal goals' (or short-term goals as discussed earlier), this type of empowerment could provide the players with an emotion of 'pride', sustaining the players' level of engagement, and through 'experiential learning' practice – demonstrating the long-term environmental conservation benefits from the economic and scientific standpoints.

However, in accordance with the difficulties & complexity aspect discussed above, empowerment concepts presented in the game should be reasonable (e.g. based on the scientifically sounded context). In other word, GEG suggests that rewards should not be allocated as the result of insignificant achievements (e.g. rewarding the players for having played the game for 2 hours).

An example of empowerment can be found in commercial games such as SIMCITY (Electronic Arts n.d.) and ANNO 2070 (Ubisoft 2011) where the players are required to gather significant amount of resources and meeting several criteria before they could be allowed to construct high-tech buildings. In turn, these buildings offer long-term benefits to the players' city (e.g. reduce operational costs and overall environmental problems in the city).

The aspect of empowerment in environmental games needs not to limit itself to Real-Time-Strategy Games (RTS) and City Management Games (CMG). It could also be used in Role-Play (RPG) and adventure games too. For example, a survival game might allow the players to purchase a solar cooker unit so that their household energy consumption and utility expenses would be reduced significantly during the summer season. Similarly, a close-breathing system can be purchased by the players to protect the main character from the effect of heavy air pollution in the city.

2.8.11 Competition & Cooperation

Multiplayer is an important game aspect as it introduces new dynamic interactions between players. Greenberg et al. (2008) has emphasized the importance of competition in games – especially for young teenagers up to adolescents (college students). As highlighted by Squire (2011), the players become aware that they are interacting with other human beings and the game environment becomes more dynamic as the course of the game is no longer bounded by the computer scripts. Multiplayer games can also encourage the players to discuss game contents and analyze their strategies constantly. This may take place either in face-to-face settings (for paperboard games) or in the online communities (e.g. Squire 2011: 131).

The researcher identifies two main components of multiplayer aspect which are: competition and cooperation. Smith (2009) has suggested that competition and cooperation can play a significant role in both cognitive and affective learning outcomes. Greenberg et al. (2008) have highlighted two types of competition which are 1) competition against others and 2) personal challenge. Fisher (1976), on the other hand, has highlighted two types of competition which are 1) interpersonal competition (player(s) against other player(s)) and 2) Intergroup competition (a group of players against other groups). Squire (2011: 175) suggested that a well-designed competition can also motivate the players to improve their skills in game-based learning environment[27].

Mayo (2007) has proposed that cooperation can contribute to effective learning. Similarly, Lin, Wu and Wang (2010) have suggested that group cooperation can encourage the players to focus on helping their teammates rather than on defeating the opponents.

As highlighted by the studies above, competition and cooperation in digital games can take many forms. For example, it can be in the form of human players against artificial intelligence (e.g. a player compete against the computer AI in a game of chess). It can be in the form of human players interacting cooperatively or competitively against other human players. It can be in the form of players attempt to reach the goal(s) set by the game itself (e.g. complete as many tasks as possible in a given amount of time).

However, the aspect of competition must be considered before being incorporated into the environmental games (and educational games in general). Some players may prefer to compete with human players while others may prefer a quiet competition with computer AI as found in an experiment of Sherry et al. (2006).

Further, competency level must be considered for the design of competition as well; the study on energy conservation by Petkov et al. (2011) has suggested that experienced players are eager to enter the competition while inexperienced users may want to wait until they can gain necessary skills for it.

Similarly, Prensky (2007: 122) has highlighted that some players may not interested in competitive aspect of the game. On the other hand, Dormann and Biddle (2009) have highlighted situations where competitions can generate pleasure for the winner, but at the expense of defeated player. This effect might demotivate some learner groups from using the learning medium.

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[27] Competition element can be linked to performance-oriented learners where contests and evaluation is the key motivation for these learners (Institute of Education University of London 2001).

Further, if player(s) VS player(s) competitions were to take place in environmental games, the nature of the competition should 'make sense' and scaffolding the learning context of environmental conservation. It should not be based on achievements such as 'the player who spent the longest game hours' or 'the top players who managed to acquire the most resources within a given timeframe'. Ruiz-Pérez et al. (2011) have reported from one of their FISHBANK game sessions where the players have rushed to maximize their economic gains (i.e. score) toward the end of the game in order to win which resulted in a rapid depletion of wild fish stock – destroying the core purpose of the marine conservation game.

Cooperation element, on the other hand, could be considered for environmental games. Smith (2009) has suggested that cooperation can promote learning outcome and intrinsic motivation of learners. For example, the game could allow the players to give or trade resources with other players online. Similarly, the environmental games could allow the players to help other players in their missions (e.g. sending in labors to help on reforestation project or share environmental-related information with other players). Ranking (as the element of competition) can be made this way based on 'the most helpful players in the region'. As highlighted in the literature chapter, environmental problems should be considered as the global issue as a number of environmental problems can spread from one region to another. Thus, environmental games could emphasize on the shared-interests in global environmental protection.

Another point of consideration for the multi-player aspect of the environmental game is the 'game-balancing'. In some commercial games for example, the developers have prioritized the game-balancing specifically designed for multiplayer games, but doing so would also sacrificed the realism in the process[28]. To this end, the balancing might interfere with the learning and / or contribute to undesirable learning outcomes if utilized improperly.

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[28] For example, the destructive powers of some firearms in some a multi-player shooting game have been intentionally lowered by the developers in order to 'balance' the overall gameplay and / or prevent expert players from relying on certain strategies. The game, thus, no longer represents the realistic descriptions of weapons in the real-world.

2.9 The learner aspect

2.9.1. Intrinsic & Extrinsic motivation

Motivation is crucial for learning performance and result (Wlodkowski 1985: 3, 5; Ambrose et al. 2010: 69; Squire 2011: 47). If successful, it is also likely that the motivated learners will utilize acquired skills / knowledge into the daily practices (Wlodkowski 1985: 4). Lepper, Corpus and Iyengar (2005) have described intrinsic motivation as "The desire to engage in behaviours for no reason other than sheer enjoyment, challenge, pleasure, or interest". Intrinsic motivation can be linked to autotelic experience – 'a safe-contained activity' as highlighted by Csikszentmihalyi (1992: 67). The importance of intrinsic motivation on learning is highlighted by Malone and Lepper (1987: 224). Extrinsic motivation, on the other hand, is concerned with external factors such as school grades and financial rewards (Ryan 2013).

Intrinsic and extrinsic motivation model also paralleled with learners' orientations model (Institute of Education University of London 2001). In this setting, the players with 'learning orientation' primarily seek to enhance the level of competence (which could be linked to intrinsic motivation) while the players with 'performance orientation' primarily seek satisfaction from competition and recognition (extrinsic motivation). Nonetheless, studies have noted that both intrinsic and extrinsic motivation can occur at the same time in the learning context (Lepper, Corpus and Iyengar 2005; Ambrose et al. 2010: 69).

As mentioned above, well-designed environmental games too, can motivate the players to enjoy the game intrinsically (e.g. pleasure from reading and acquiring new information and observing visual designs of the game, among others). It can also drive extrinsic motivation by offering the learners with new knowledge sets that can be transferred into the real-world (e.g. learning about energy / water conservation to minimize the utility cost).

However, it should be noted that extrinsic motivation of the players can be discouraged or encouraged by the real-world factors as well. For examples: 1) government's stance and supports towards the sustainable development (e.g. government's performance on promoting environmental campaigns and apprehension of environmental crimes) 2) the price of new technology (e.g. the capital cost, break-even-point, and long-term benefits) and 3) level of participation in the community and cultural background[29].

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[29] Centre for Alternative Technology (2010: 147-181) noted that the real-world factors such as personal responsibility, social and cultural constrains can promote or inhibit sustainable behaviours.

This means that other real-world obstacles must be overcome at the same time in order to encourage the pro-environmental behaviours. To this end, existing real-world environmental frameworks such as the 4E (Enable, Encourage, Engage, and Exemplify) model (Defra n.d.(a)) and Rothschild (1999)'s Education, Marketing, and Law model could be promoted into the environmental games to help create a meaningful link between the game scenario and the real-world situation.

2.9.2. Passive, Active and Experiential Learning

In GEG learning aspect, the researcher identifies three major instances in which the learning can take place when using the environmental games. These are 1) Passive Learning (e.g. McFarland et al. 2013), 2) Active Learning (e.g. California State University 2007), and 3) Experiential Learning (e.g. Mayo 2007) respectively.

2.9.2.1 Passive learning

Passive learning represents situations where the players read or listen to in-game dialogues (e.g. reading about the game background story or a mission brief before taking on a quest). While some educators have noted that passive learning may not be an effective method due to the lack of participatory requirements, some evidence have indicated that passive learning can be used in conjunction with other learning paradigms to enhance learning. For example, Gee (2003) and Squire (2011) have observed that playing the game can motivate the children to seek out additional reading materials to further their understanding of the game content. Similarly, Csikszentmihalyi (1992: 121) has indicated that the pleasure can be gained simply from remembering the new set of information.

For this, the researcher proposes that textual (or audio) information could be embedded within the environmental games to supplement the learners in what Gee (2003) called 'on demand' information. The information might be put in an 'encyclopedia' format where the players can browse through the game's 'library' or it could be embedded with the game objects so the players can request for the information immediately (e.g. right-click on a tree while playing the game brings up information such as scientific name, characteristics, economic importance, ecological functions, and conservation status).

2.9.2.2 Active learning

Active learning, on the other hand, involves participation, interpretation, and decision making with the game contents. Classic examples are games with quiz or puzzle mechanisms[30]. A study of a multiplayer paperboard game had suggested that quiz-based games can be engaging, challenging, while promote learning at the same time (Arslan et al. 2011) (also see Arnab et al. 2012). 'Question-based Learning' can be an engaging activity as suggested by (Prensky 2007: 161). Depends on the design, quiz can also be linked to the 'Frequency of Repetition' and 'Reinforcement' as highlighted in Hilgard's principles[31] (Knowles, Holton and Swanson 1998: 74). Similarly, Keller (2010: 47) has linked quiz with the 'Inquiry arousal' which could be used to promote the learners' curiosity and attention.

As discussed in the 'feedback' section, the key advantage of utilizing the digital technology is that the quiz can send feedback to the players instantaneously. This is a crucial element to sustain the players' confidence (e.g. Csikszentmihalyi 1992: 49; Keller 2010: 52). Five types of feedback systems for learning have been proposed by Dempsey, Driscoll and Sales (1993) which could be considered for the quiz-based learning games (Please refer to THE GROWTH chapter for details).

2.9.2.3 Experiential learning

Finally, the experiential learning is concerned with 'learning by doing' (e.g. Mayo 2007; Arnab et al. 2012). In GEG model, environmental and social variables could be simulated to highlight interrelationship between the environmental degradation, the socio-economic constrains, health, and well-being issues (also see the 'dynamic gameplay' section of this chapter).

For example, the game could incorporate a game mechanism where the players are given a choice to deforest an area in exchange for a substantial amount of short-term financial incentive – but at the cost of long-term social, environmental and financial setbacks (e.g. vulnerability to floods and draught, ecological degradation, and the lack of steady incomes from forest products). Similarly, the game could present to the players with options to promote environmental campaigns, strengthen

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[30] As discussed in literature review section, examples of games with quiz mechanism include: ENVIROPOLY (Arslan et al. 2011) and HONOLOKO (European Environment Agency n.d.).

[31] THE GROWTH, for example, expects players to spend considerable efforts and time answering the quizzes (in exchange for in-game rewards). Also, quizzes that have already been answered by the players may return to the game, allowing the players to recall and retain the content through 'overlearning' (e.g. Knowles, Holton and Swanson 1998: 74).

environmental regulations, or 'do nothing' (whereby the last option allows pollution problems to build up and eventually trigger natural disasters).

2.9.3. Age groups

Depending on the players' subjects of interest, the level of intrinsic and extrinsic motivation may vary across age groups and from one person to another (e.g. Ryan and Deci 2000). This is also an important factor to consider when designing an environmental game. The researcher suggests that multiple types of environmental games (and other environmental-related messages) should be deployed to reach different population group. Environmental games targeting young children may be differed in context and presentation when compared to environmental games targeting adolescents and adults (e.g. the concept of financial and health benefits from environmental conservation might not be attractive to the children and young adolescents).

In this regard, some aspects in GEG such as the financial, health, and social benefits have been designed specifically to appease the interests of some adolescent and adult groups. The rationales behind this decision include: 1) adolescents and adults might be able to grasp the concept interactions such as environmental degradation, social issues, health and quality of life, law and policy, and technological advantages at better rates when compared to children, 2) adolescents and adults might be more persuadable towards the sustainable lifestyle paths under the offer of financial incentives, societal and health-well-being, and moral obligations (to some extends), and 3) adolescents and adults have more responsible and freedom over their actions when compared to children (e.g. paying their own rents and setting up life-goals).

However, one obvious implication for developing environmental games targeting this group can be attributed to the fact that adolescents and adults have freedom over their choices (i.e. they are not bounded to learn in a similar fashion to the children). They are also occupied by rigid commitments (e.g. study and work schedules). Thus, the value provided by the game must be clear and profound in order to convince them to use the game in the first place. This argument is supported by Lepper, Corpus and Iyengar (2005) who have reported that intrinsic motivation may decrease in older learner groups. Similarly, Wlodkowski (1985: 18) has suggested that older learners want "to do, produce, or decide something that is of real value to them". Similarly, other researchers have suggested that adults can be motivated by extrinsic factors such as wealth and career advancement, but noted that factors such as self-esteem and quality of life are the main motivators (Knowles, Holton and Swanson 1998: 68). Thus, GEG was developed with a focus on practical, real-world knowledge that players can adopt into their daily lives.

2.9.4. Gender

The relationship between gender and gaming preferences has been a topic of interest to the game researchers for some time (see Harteveld et al. 2014). Studies have indicated that gaming activities are more prominent among males than females – perhaps this can be attributed to the fact that the game industry is largely dominated by male developers with the primary target on male consumers (e.g. Greenberg et al. 2008). However, Carr (2005) has suggested that gender alone may not be an adequate indicator for gaming lifestyle and demonstrated that gaming preferences in female may change over time. Squire (2011: 171-172) had obtained similar evidence that the females may play and enjoy stereotype 'boy games' (e.g. fighting games) and suggested that factors such as social background, culture, and age of players should be accounted for as well.

2.9.5. Cultural & Social values

Cultural and social values are important aspects to consider when designing environmental games. Even the benefits provided by sustainable technologies can be rejected based on cultural beliefs and traditions (e.g. Coyle 2006). Efficiency in resources management is critical for environmental conservation effort, but it can also implicate well-being issue in some cases. For example, the use of food waste for animal feed represents an efficient use of resources. The practice is considered acceptable and widely practiced in many Southeast Asian countries and in the US while the practice is prohibited in the UK and European countries over the contamination concerns (Defra n.d.(b)).

Linking to the growing population issue, another example of environmental-social value is the preference for multiple children in some cultures. Parts of this belief hold that children will work, care for their parents, and continue family's legacies as they grow up and take responsibilities. However, this belief also raises the questions of family well-being should financial difficulties arise. At the same time, the rejection of contraceptive devices can be stemmed from religious reasons – as well as misconception[32] (e.g. Siegler et al. 2012).

While it is very difficult for the game to consider multiple cultural and social values at the same time, the games can still maintain faithful scientific objectives in addressing socio-environmental implications without aggravate cultural and social values (e.g. fruit and vegetable-based diets could be promoted based on health and environmental benefits rather than being promoted as an aggressive campaign for animal rights).

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[32] Similarly, a report has suggested that strong cultural beliefs can seriously hamper health and well-being of the population (Discovery News 2014).

2.9.6. Community Supports

The importance of facilitators / educators in the traditional learning setting have been promoted by educational researchers (e.g. Wlodkowski 1985; Knowles, Holton and Swanson 1998; Keller 2010; Ambrose et al. 2010). In general, many researchers have agreed that facilitators / educators should be able to motivate, illuminate, and support the learners with genuine compassion.

However, significant portions of digital games are being experienced by the players in private settings – limiting the role of human facilitator (especially in single-player games). To this, online communities such as webboard can be a useful facet where experienced players can become 'mentors' for other players. A number of evidence from online webboard have demonstrated that game mechanism, strategies, and even the game narratives are being discussed by a number of players online (personal observation).

One major advantage of community support is the anonymity nature of the online community where the players can ask and discuss the questions without being physically alienated by their age and other social orientations. This setting can be especially useful for the adult learners. However, one of the main implications for learning from the online community is the issue of validity where the information provided might be incomplete or incorrect. This implication is further supported by Ambrose et al. (2010: 10) who highlighted that learning obstacles can emerged from misconception, incorrect, and incomplete set of information. Although a costly solution, one of the methods to tackle this issue is to deploy topic experts to provide elaborated and scientifically-sounded evidence for other players. This strategy is already being deployed in some non-game online communities where health-related information is provided / clarified by the licensed scientists and medical doctors.

2.10 Conclusion

In this chapter the researcher has discussed the components of Guideline for Environmental Games (GEG). The guideline, in turn, was inspired by a number of environmental theories, learning and motivational theories, game theories, as well as the recent game development techniques from both the serious and commercial game camps.

At the basal level, the GEG shares some common features to other serious and commercial games (e.g. the context, the goal, the randomness and uncertainty). However, the GEG proposes that these common features / game elements must be interpreted specifically in the environmental context to create effective environmental learning applications. For examples: 1) the context of environmental games serves not only the setting for the game, but should also be relevant to the target group(s) to

encourage the players to recognize the environmental and social issues within their immediate surroundings[33], 2) the context should maintain neutrality based on scientific evidence to avoid players' rejection and / or alienating certain target groups, and 3) certain design options could promote different learning and motivational outcomes, and therefore, must be considered carefully. These examples demonstrated the needs for specific strategies required in serious environmental game designs.

As emphasized at the beginning of this chapter, certain elements within the GEG require the game developers to choose from different design options. Available options are dictated by a number of circumstances such as choosing the genre of the environmental game, the developers' resources (time & budgets), and the target group(s).

The next chapter will discuss THE GROWTH – a prototype environmental game developed based on the GEG. This prototype game was later tested to evaluate the educational and motivational values of both the GEG and the prototype game itself.

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[33] The context must also draw the players to other transferrable global environmental issues at the same time.

3. THE GROWTH

3.1 Introduction

This chapter discusses in detail about THE GROWTH's game mechanism. THE GROWTH is a prototype environmental game with a special focus on the growing human population issue. In turn, the game development was guided by the newly proposed 'Guideline for the Environmental Games' (GEG) discussed in the previous chapter. Aligning with the study's research questions on the players' knowledge and motivational outcomes, THE GROWTH serves as a 'test-bed' to validate the GEG (and THE GROWTH itself) in term of its educational and motivational values in the environmental learning context.

After the game mechanism section, this chapter discusses the link between THE GROWTH, the layers of learning activities, and the GEG. Towards the end, this chapter discusses the preliminary outcomes obtained from the participants during the pilot evaluation phase.

3.2 THE GROWTH: Overview

THE GROWTH is a single-player real-time sandbox environmental management game. As suggested by the name, THE GROWTH is a serious game with a special focus on the growing human population and its impact on the natural environment. Additionally, the interrelated issues related to the environmental degradation such as the aspect of social well-being and the economic impacts originated from the unsustainable lifestyles were also highlighted in the game.

'Sandbox' is a term frequented by the gaming industry / communities. It is associated with games that allow the players to exert their actions / influences on the game world with a relatively wide degree of freedom (while still limited to certain game rules). The 'management' part of the game means that the players will take the role of environmental managers who oversee the situation from a broader perspective (see SIMCITY and ANNO 2070).

Instead of a strict focus on the 'environmental-only perspective', THE GROWTH takes an alternative approach that environmental games should be able to highlight the social and economic factors involved in the environmental conservation process as well.

The newly developed Guideline for Environmental Games (GEG) was used to guide the development of THE GROWTH. In turn, GEG is based on existing game, motivational, and learning theories as previously described in the GEG chapter.

THE GROWTH shares basic game mechanisms to several prominent city-management games highlighted in the literature review chapter. For example, THE GROWTH highlights the interrelationship between the human activities and the environmental degradation which is quite similar to ANNO2070 (Ubisoft 2011) and SIMCITY (Electronic Arts n.d.). THE GROWTH also encourages the players to partake in resources gathering and expand financial capacity in similar to the MONOPOLY (Hasbro 2013).

THE GROWTH is presented from a far, 'bird-eye view perspective'. This aspect was chosen to visualize the vast extension of human habitats to the players. However, unlike commercial games such as SIMCITY and ANNO 2070, THE GROWTH does not incorporate game aspects such as free-form construction and landscape manipulation. Instead, the game uses a pre-defined city that the players may influence upon. This approach shares some similarity to ENERGYVILLE, a serious game addressing energy issue (Chevron-EnergyVille 2011).

To justify this approach, THE GROWTH has developed a storyline to explain that the environmental condition in the game world is reaching a critical situation where the humans can no longer afford to expand further into the natural habitats. Instead of expansion into the natural habitats, players who wish to dominate the political influence of the region must seek to do so by taking over other business.

The key message of this game, while not explicitly express, is for the players to acquire all available financial and political resources so that these resources could be used for the environmental conservation and social development efforts.

THE GROWTH incorporates an elaborated storyline. Players start the game as the newly elected leader of an environmental organization. The organization, in turn, is a front-organization for the government established to preserve and restore the natural environment in the region. The players' key objective is to maintain positive environmental condition within the region. However, as the main focus of the game is centered in the growing human population issue, the players must also consider strategies for societal improvement as well. This part aims to highlight the relationship between the natural environment and the societal well-being (e.g. Donohoe 2003, Guillebaud 2007, Center for Alternative Technology 2010).

In concurrent with the 'localization' aspect highlighted in the GEG, THE GROWTH's content is centered on the environmental and social events in Thailand. However, the environmental and social issues from the global perspective were also included to highlight the transferable environmental and

social problems. The game is available in both English and Thai languages. Manual translation was performed by the researcher in order to avoid possible errors associated with computerized translation systems (e.g. Dunwell et al. 2012: 59).

THE GROWTH was developed with UNITY 3D Game Engine (Unity3D 2012). This game engine was selected because of its high-fidelity and intuitive work pipeline (Petridis et al. 2012). Also, the game engine has satisfied all technical criteria required by THE GROWTH project.

THE GROWTH requires a medium-grade computer system with 3D Graphics Processing Unit (GPU) to operate. During the experimental sessions, the game was operated at 1280 x 768 screen resolution on a 32-bit Windows XP operating system (Service pack 3).

3.3 THE GROWTH: Key features

In term of game concept design, THE GROWTH utilizes several aspects that set it apart from many environmental games. The following are the key features of the game:

- A special focus on the growing population issue: demonstrating the relationship between the growing human population and the environmental degradation. The game also highlights the societal, health, and well-being issues stemmed from the resources competition.

- Demonstrate the impacts from the environmental problems in global terms. For example, the region might experience the pollution storm which spread from the neighboring regions.

- Highlight household-level actions that can be utilized to minimize the environmental and health problems while help conserve financial assets at the same time. Apart from introducing the players to sustainable technologies, THE GROWTH highlights a number of pro-environmental actions that can be used to improve the natural environment and the societal well-being at the same time. For examples: recycling can minimize the environmental problems while help improve the efficiency of waste recycling operation (of the city) at the same time. Another example is the introduction of water / energy awareness campaigns to conserve natural resources and save utility expenditures at the same time.

- Inform the players of possible actions that can be taken to tackle environmental and social problems at the regional scale. For example, by initiating 'The Environmental Education Policy', the players can implant the long-termed environmental awareness to the children and teenagers.

This increases the long-term participation in recycling as the children and teenagers may start to transfer environmental knowledge to members of their family and to others in the community. As a result, this improves the environmental condition in the region.

- On the other hand, unconventional policies such as the 'Managed Hunting' and the 'Legalize Trade in Wild Animal Carcasses' policies can open up new financial opportunities for the player. In turn, the amount of financial resources can be used to fund the environmental conservation projects (e.g. Lindsey et al. 2006, Lindsey, Roulet and Romanach 2007). However, some environmental groups may see this as an indirect threat to wildlife protection efforts (e.g. Tilson and Nyhus 2010) and withdraw their supports from the players.

- Highlight the long-term benefits from investment in the environmental-friendly technology. For example, solar powered devices and water-efficient appliances can be installed in player-owned properties in order to minimize the pollution and the utility expenditures in the long run. Apart from high-tech equipment, THE GROWTH also draws the players to the common but innovative sustainable equipment such as washable plastic bags and hand-pump bidet shower.

- Inform the players of the technological limitations. For example, the game demonstrates to the players that the outputs from the renewable energy sources such as the solar and wind energy can be unreliable (e.g. low wind speed / cloudy sky). The game also demonstrates the importance of reliable and sustainable energy storage system that can be used to improve the efficiency of renewable energy sectors (e.g. compressed air energy storage and flywheels). The game also demonstrates that technologies can malfunction and also require maintenance. For example, unmanned aerial vehicles (UAVs) can be used to prevent the environmental and social crimes. However, risks of malfunction exist (e.g. crash) where players will need to pay a high price for the maintenance / replacement.

- Inform the players of the short term benefits from unsustainable activities VS the long term benefits provided by nature. For example, some game actions allow the players to boost their financial capability at the cost of rapid environmental degradation.

- Raise awareness on the importance of wildlife and natural habitats (i.e. the biodiversity) as a vital factor for the global ecosystem. Already, many environmental groups have promoted wildlife conservation based on attractive appearances and other desirable characteristics of plants and

animals. THE GROWTH, however, takes a different avenue by emphasize the importance of the wildlife and natural habitats conservation based on ecological functions, long-termed economic values, and scientific interests. For example: the natural habitats, plants, and wildlife species can be promoted based on the economic standpoint (e.g. FAO Forestry Paper 169-2012, Cisneros-Montemayor et al. 2013). Additionally, animals and plants conservation can be promoted based on their economic and ecological values.

To this, the financial and scientific benefits of environmental conservation are demonstrated in THE GROWTH. For example, the players can initiate the 'ecotourism' campaign in the region to generate extra income. The income then can be used on various environmental conservation projects. Also, the players can set up a small laboratory on an off-shore installation. Scientific data gathered from this laboratory then can be shared with scientific institutions in exchange for financial supports. This design approach was inspired by Whitton (2010) who highlights the importance of 'neutrality' in game-based learning. With this stance, THE GROWTH aims to attract the non-environmental conscious players to the context of environmental conservation.

- Emphasize on the importance and the nature of the public cooperation. Certain social and environmental campaigns in THE GROWTH do not provide immediate / constant benefits to highlight the unreliability in public cooperation. For example, the 'Forest Protection Campaign' may or may not encourage the public to participate in forest re-plantation activities (or donate to support the campaign financially). In another example, the 'Recycling Campaign' may or may not encourage members of the community to practice recycling.

- Reflection to real world environmental and social issues. Game objects in THE GROWTH are based on scientific information in the real-world so that the players may review in order to gain additional information. For example, the game object 'Food Storage Facility' is linked to the recent real-world development in food preservation technology (e.g. using hyperbaric storage and improved insulation to minimize energy consumption while extend products' shelf life). The game also informs the players about food situation worldwide such as starvation and malnutrition rate, food wastes (caused by inefficient food production and distribution), and the projected food demand for the future.

- Highlight unconventional policies and emerging technologies that can be used to tackle environmental and social issues. For example, the game presents the advantage of a new business

model that converts food waste into animal feed which helps reduce pressure on the natural environment while generating financial income at the same time (e.g. AgriProtein 2012).

- Highlight the risk of disease outbreaks caused by the high-density population and global trades. Disasters such as contagious diseases can make appearances in the game. This include plant diseases (transmitted via the global transportation), Animal diseases (caused by intensive farming practice), and contagious diseases affecting human population. The risk of disease outbreaks can be partially prevented by players' actions (e.g. enforcing disease prevention program to minimize the risk of disease outbreak)[1].

3.4 THE GROWTH: Context

THE GROWTH's context is informed by a number of scientific environmental and social studies. These can be categorized into four main groups which are: 1) The growing human population and the environmental impacts, 2) The social welfare & security issues, 3) The remaining natural resources, and 4) The environmental & social improvements.

3.4.1 Growing human population and the environmental impacts:

With more than 7 billion worldwide (United States Census Bureau 2011), it is necessary for the public to recognize the negative consequences of unsustainable population growth and its impacts on the natural environment. Examples of these consequences include the rapid resources consumption and the depletion of natural resources (Donohoe 2003), declining forest lands (Grau and Aide 2008, Donohoe 2003) declining water resources (Gleick 2003, Hanjra and Qureshi 2010) and increasing volume of wastes (e.g. EEA 2005, United States Environmental Protection Agency 2012).

The growing human population issue is the central theme of THE GROWTH. This issue is one of the main contributors to the rapid resources exhaustion and ecological degradation in the game. Ultimately, the game demonstrates that the negative consequences are reflected back to the society in the form of pollution, disasters and social vulnerabilities.

With regard to the growing human population, THE GROWTH incorporates exponential population growth model. That's it – the population size will expand at accelerated speed if left unchecked.

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[1] To promote societal well-being, the impact from disease outbreaks in THE GROWTH outruns the environmental benefits from population reduction caused by deaths from the diseases.

Larger population sizes consume resources and degrade the natural environment faster than small or medium population sizes[2].

3.4.2 Social welfare & Security:

According to a report from World Food Programme (WFP), about 840 million people worldwide are suffering from hunger and malnutrition (World Food Programme 2014). Also, another report has predicted that hundreds of millions worldwide would be vulnerable to malnutrition and starvation as a result of the climate change in the near future (STERN 2006: vi). For this, families with insufficient and limited financial security will be at greater risk of welfare problems when compared to other groups (Ackerman 1999, World Development Report 2010). A recent study also suggested that unsustainable population size can magnify these risks as well (United Nation Population Division 2011).

THE GROWTH acknowledges a direct link between the ecological disasters and the negative consequences on the society. To this, THE GROWTH presents a wide array of social issues to the players. Social issues in this game are grounded in case studies and reports from around the world. Examples of social issues in THE GROWTH include: crimes and social violence, narcotics, human trafficking (e.g. slavery, forced prostitution, and organ trades), unplanned pregnancies, parental responsibility, mental health, children welfare, financial vulnerability, and health problems caused by environmental contamination among others.

3.4.3 Remaining natural resources:

Natural resources around the world are in rapid decline mainly due to the unsustainable human exploitation (Donohoe 2003, OECD 2008). The natural resources consumption is projected to increase in the future (de Fraiture 2010). Apart from food, water, fuel sources, and raw materials, plants and wildlife species are being threatened by human activities and are at imminent risk of extinction (e.g. IUCN 2007). Also, resources shortages can lead to social disturbances.

3.4.4 Environmental & Societal improvements:

Nurturing the region, maintaining the positive environmental condition, promoting sustainable policies and technologies, and promoting sustainable population size are key objectives for the players in THE GROWTH.

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[2] For example: The population size of 5,000,000 in THE GROWTH will drain the emergency supplies and degrade the overall environmental condition in the region faster than the population size of 1,000,000.

For example, the recycling campaign can be initiated to improve the overall environmental condition in the region. Similarly, family planning programs can be initiated to decrease the population growth. Also, in later game stages, players can influence the political sphere by lobbying for environmental and social policies (e.g. declare and area to be a protected forest, and discourage the use of plastic bags in the supermarkets).

Apart from the campaigns and policies, technology plays a crucial role in THE GROWTH. The game introduces a number of sustainable technologies that can be used to bring beneficial effects to both the society and the environment. Technology in this game can range from automated and computerized system (e.g. using precision production robots to decrease industrial wastes) to energy and water efficient system (e.g. improved household insulation and water leakage sensor) to sustainable product designs (e.g. waterless toilets).

Some technologies presented in this game are based on the working prototypes of innovative applications. For example, the game allows the players to utilize a new technology which can reduce air pollution in the region. In turn, the technology is based on a new technology developed by a team of scientists in the US. (see The American Chemical Society 2013).

3.5 THE GROWTH: Storyline

As highlighted in the GEG chapter, the setting and the storyline can play an important role in games by introducing the players to the game world and help produce certain emotional outcomes.

For this, THE GROWTH has incorporated the storytelling mechanism. The setting explains the history of human expansion and its impact on the natural environment. The story describes the current situation where the unsustainable human population size along with the rapid consumption and habitat expansion has contributed to significant environmental, health, and social problems. The following narrative serves as an introduction story:

THE GROWTH is centered on a large coastal habitat simply refer to as 'The Region'. The region is comparable to an island nation in the real-world. There are also other regions in THE GROWTH which are being referred to lesser extends.

The realm of THE GROWTH can be interpreted as an alternate reality to Earth. Humans are the dominant species on this planet. The year is 2030 and humans have already mastered a number of advanced technologies. However, the size of human population continues to grow – along with the

increasing demands for energy, water, foods, medicines, minerals and other commodities. Wastes, on the other hand, are being deposited at rapid pace and have already exceeded the disposal capacity.

Humans are facing many eminent environmental issues at the same time. Despite the impending environmental degradation caused by human activities, the needs of humans in the region (as well as other regions) continue to grow at rapid pace and the few remaining natural reserves are being threatened. The government is failing on its waste management programs and the toxic wastes are being either illegally deposited into the ocean or spread into the terrestrial environment. Due to the deteriorating environmental conditions, wildlife species are disappearing at noticeable rate while many other species have already been pronounced as extinct by the scientists.

Despite advanced technologies, the global agricultural productions are experiencing yield reduction. This is due to the combination of environmental problems. Food crops and livestock are weakened by the unpredictable temperature and climate patterns. Additionally, the frequency of disasters such as flood and draught is increasing and causing impacts on the food production worldwide. At the same time, the fertile agricultural sectors are being affected by the pollution contamination. These problems can be attributed to the excessive use of toxic pesticides and other chemicals from both the residential and industrial sectors.

To mitigate the food problem, some foods are being produced in the isolated, climate-controlled environments (e.g. greenhouse). This technique helps shield the products from the environmental hazards such as pollution, undesirable temperatures, and pests. However, this technique requires a substantial amount of capital investments when compared to the conventional agricultural practices. As the result, foods produced in climate-controlled settings are considerably more expensive and affordable only by the wealthy population groups.

Pollution generated by the humans also contributed negative impacts on the society as well. Health problems such as the respiratory problems, brain and nerves damage, diarrhea, spongy bones, and kidney failure can be traced back to the magnifying pollution issue.

Many new diseases have emerged and some have gained resistance against antibiotics. This is due to the excessive use of antibiotics in humans and farmed animals which resulted in the mutation of many diseases and pathogens. Further, densely populated human habitats the region have facilitated the spread of diseases. Only few cures have been discovered by the scientists so far. Many patients are suffering from these antibiotic-resistant diseases. In order to combat the spread of diseases in

high-density public space, health education, and sanitary practices are being promoted to the public by the government.

The region is experiencing a relatively high unemployment rate due to the global economic uncertainty. The cause of unemployment can be partially attributed to the shift from labor to automated industry. Living costs are increasing due to the raise in consumable and utility prices. According to the statistics, more than 18% of the region's population is now living below the poverty line while another 26% are experiencing moderate financial difficulties. Without resources, many are resorting to crimes, leading to a number of social problems.

Contrary to the prediction, the world population continues to grow despite the combined problems of resources depletion, social disturbances, and economic difficulties. Due to the limited information on the contraceptive devices and family planning, about 46% of pregnancies in the region are unintended. Also, pregnancy rate for the young parents below 20 years of age are on the rise. Many families continue to have a large number of children despite imminent risks of financial difficulties. The regional statistics have indicated that a large number of children are experiencing various welfare issues.

Common contraceptive devices are currently being sold by pharmacies at reasonable price. However, many teenagers and adults have declined to use contraceptive devices due to misconceptions. Further, pre-marriage sexual relationship is being viewed by many people in the region as an unspeakable and unacceptable subject. This tradition deprives many teenagers the opportunity to seek advices from parents and relatives. Instead, these teenagers are depending on trials and errors which sometime result in serious and permanent physical incapacity or the death of both the mothers and the unborn.

As the last resort to hold the environmental problems, the government has built a gigantic experimental underground facility that acts as a vault to keep the highly toxic wastes within. The purpose of this project is to 'buy the time' until the scientific breakthrough in waste management can be developed.

Unfortunately, a serious explosion occurred at the facility just several months after. The main explosion was followed by series of violent seismic activities in the region. This incident has damaged a number of underground toxic containment units – spreading a large amount of toxic pollution around the vicinity. The violent chemical reactions have resulted in the collapse of an entire

district which the underground complex rested upon. Fortunately, the majority of workers have managed to evacuate from the district before the last explosion.

However, over 12,000 workers have perished and more than 300,000 have been immediately affected by the deadly pollution. The majority of the deaths were 'volunteered' workers who have been tasked to dismantle and remove valuable equipment from the now abandoned factories. Toxic and radiated particles were blown into the air and spread into both the natural environment and the human habitats alike. At the same time, millions of people are suffering from health problems. Also, the concentrated amount of pollution has turned buildings into yellowish color. This incident is later known as 'The Great Disaster'.

Figure 3.1: An in-game static image from 'introduction' section depicting a large area collapsed in the catastrophic event known as 'The Great Disaster'.

3.6 THE GROWTH: Theme and setting

The world of THE GROWTH is set in a hypothetical region populated mostly by human constructs such as the stretches of roads, utility infrastructures, building blocks, and manufacturing plants. As mentioned earlier, the players see the game world from a 'bird-eye far-perspective' view.

The players arrive into the region after 'The Great Disaster' event. To this, all buildings in THE GROWTH have already been affected by the pollution. Most buildings are coated in yellowish color with crispy textures to represent the effect of pollution dust on human habitats (except for buildings located far away from the ecological disaster zone). This design aspect was inspired by the 'cause-and-effect' element as described by Carson (2000) as an important element to draw the players into and engage with the game world.

Buildings in THE GROWTH can be categorized into three groups: The first group is consisted of skyscrapers and large manufacturing plants. These large buildings are designed to appear imposing as they represent the places of power for the elite members of the society. The second group is consisted of medium-sized buildings with some details on them. These represent business and premises of the medium-high income population group. The third building group is in a sharp contrast when compared to other two groups – buildings from the third group are significantly smaller in size, lack the details, often arranged in high density, and on many occasions – they are shaded by the shadows of significantly larger buildings. These buildings represent the diminished living conditions where the vulnerable and the poor are dwelled in.

Figure 3.2: A static image from the game depicting a residential district within THE GROWTH. Note the variety of buildings arranged in high density.
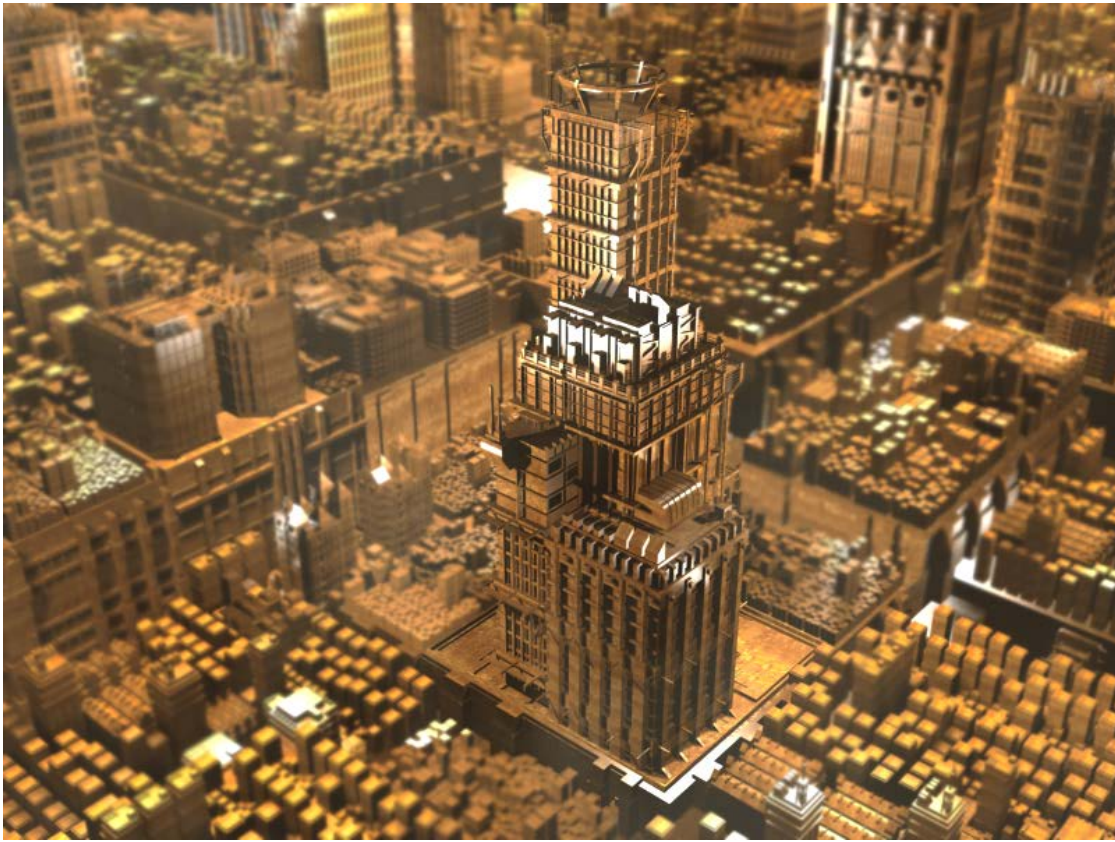
As highlighted in the GEG chapter, the environmental storytelling (i.e. visual and audio representation) can be a crucial element in the game due to its association with the implicit learning paradigm. Overall, the design of buildings in THE GROWTH utilizes familiar shapes and symbols often portrayed in film, video games, and other media platforms. For example: chimneys, networked pipes, generator units, turbines, and chemical tanks often represented manufacturing plants. Similarly, window frames, antennas, ventilation units, and external decorations are common elements associated with the residential and office buildings.

Furthermore, many buildings in THE GROWTH (especially the large buildings) are completed with fortified walls, barbed wires and watchtowers. These defensive measures signify the heightened crime rates and a sense of public insecurity in the region.

In contrast to the human habitats, a number of remaining natural habitats in THE GROWTH are spared from the adverse effect of the pollution dust (fortunately due to their distance from the

ecological disaster zone). These natural habitats are presented as fertile lands, mountainous slopes, tree patches, and contain a number of wild animals. In some cases, light man-made objects such as flood gates and observation posts are presented within natural habitats. The interpretation is left to the players as this can be perceived either as humans' efforts to protect the natural environment or a direct attempt to interfere with it.

Figure 3.3: A static image from the game depicting a natural reserve. Note the light man-made structures in the image (satellite uplink antenna and the flood barriers).

3.7 THE GROWTH: Player role

In THE GROWTH, players assume the role of the leader of a prominent environmental organization known as 'The Environmental Consortium' or TEC. It is the players' duty to maintain positive environmental condition within the region. At the same time, the players must fortify the region against both the external and internal environmental threats.

From interacting with a game object (the TEC Headquarter), the players learn that TEC is formed by the merger of many small and medium-sized environmental organizations. Former leaders of these

environmental organizations are now serving as TEC's program managers and board of directors. Apart from environmental projects, TEC is also an active investor in social and sustainable technology projects. This is because TEC recognizes the society and the scientific community as the vital parts for the environmental conservation.

In reality, TEC is backed by the government who provides the organization with financial and political supports. Due to its close ties with the government, TEC can be considered as the government's front organization in the war against the environmental problems. Apart from the government, TEC also enjoys close relationship with and receives supports from various environmental organizations and scientific institutions.

3.8 THE GROWTH: The game mechanism (summary)

THE GROWTH comes into contact with multiple issues (e.g. environmental, social, political, technological, and economic issues). These aspects can interact and influence each other, creating a degree of dynamic interactions as discussed in the GEG chapter (also see Prensky 2007: 123).

THE GROWTH presents a number of choices that can be utilized by the players, each choice contributes a unique effect(s) and can influence the game to certain extends. This idea was inspired by Gee (2003), Gee (2005), and Koster (2005: 120) who have highlighted a relationship between the high-level of game interaction and the players' positive motivational outcomes. Nevertheless, Malone (1980: 9) has highlighted that while freedom of choices can be utilize to enrich the game environment, it must be used cautiously and in conjunction with structured part of the learning. The following section describes characteristics and attributes of each game function.

Figure 3.4: The core logical framework of THE GROWTH
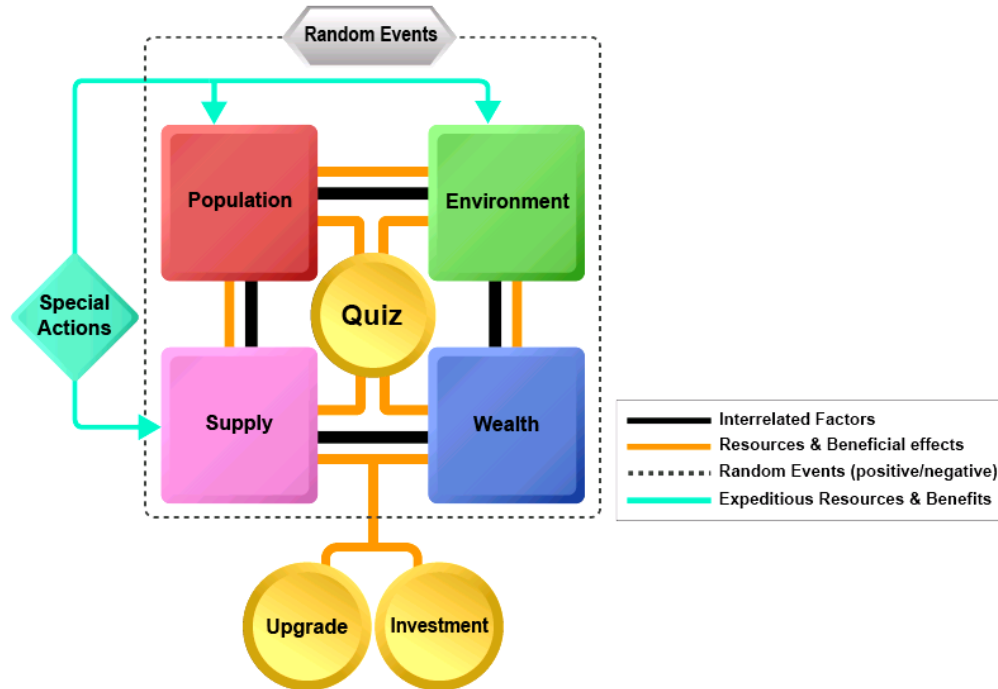
There are four key factors in the game which are: Population, Environmental, Supply, and Wealth factors. These factors interact with each other as the game progresses. For example: the unsustainable population growth contributes to the rapid environmental degradation and the increased supply consumption.

'Quiz' is the core game activity. This is the main avenue for the players to gain in-game resources (i.e. supply and wealth). The players will be rewarded with resources after each correct answer. Resources then can be used to alleviate the environmental and social problems in the region. Further, the players can spend resources on a number of 'Upgrades' and 'Investments' available in the game to gain many long-term benefits.

'Special Actions' can be issued to mitigate urgent problems in a short period of time. However, Special Actions require substantial amount of resources, and thus, cannot be used repetitively. 'Random Events' may occur as the game progresses. Some negative random events such as the disease outbreaks and the armed conflicts can be partially prevented while other major disasters such as earthquakes and floods are beyond the players' control.

3.8.1 THE GROWTH: Game mechanism (in detail)

Game mechanism and functions in THE GROWTH can be broken down into 8 topics as the following:

Table 3.1: The main components of THE GROWTH game mechanism

3.8.2 The Main Game Factors	3.8.6 Investment Function
3.8.3 Special Action Function	3.8.7 Random Event Function
3.8.4 Quiz Function	3.8.8 Time Speed Function
3.8.5 Upgrade Function	3.8.9 Save Game Function

3.8.2 The Main Game Factors:

Game factors in THE GROWTH can be compared to the characters' vital signs (e.g. player's health and stamina). Game factors represent the status of important factors within the region. There are four main factors in THE GROWTH. These being: 1) The population factor, 2) The environmental factor, 3) The supply factor, and 4) The wealth factor.

The population and the environmental factors can be seen as a form of 'The controlling aspect of rewards and communications' (Ryan, Mims and Koestner 1983) where the players are being pressured by the time and other dynamical constrains to maintain sustainable population size and positive environmental condition in the region. At the same time, the 'Supply' and the 'Wealth' factors can be seen as a mixture between 'Task contingent reward' and the 'Performance-contingent reward' (Ryan, Mims and Koestner 1983) where these resources factors will be awarded to players based on each successful game activity / performances that the players may have completed.

Figure 3.5: An in-game GUI indicating the population factor (red), the environmental factor (green), the supply factor (pink) and the wealth factor (dark blue). Note that only the supply and the wealth factors are represented in numeric. The game emphasizes that the population and the environmental factors are masked by many hidden variables, and thus, impossible to represent themselves in the numeric form. The small arrow icons at the end of each tab indicate the increase / decrease of each game factor.
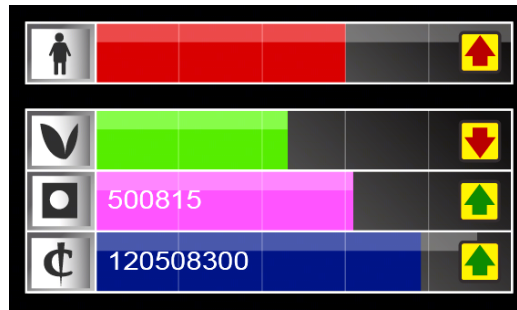
3.8.2.1 The population factor (PF):

The population factor (PF) is symbolized as a human figure. The tab of this factor is highlighted in red color. PF represents an estimated total population living in the region. Unlike supply and wealth factors, population can only be presented as estimated bar. Because the exact and accurate population counts can be very difficult to archive, this represents the real-world situation in some countries where the national census department have failed to register many residents and immigrants to the system (personal observation).

In term of the game mechanism, PF is unique from other game factors in the way that the players must balance the population level with the resources and the environmental condition within the region. Unsustainable population growth will contribute to a minor positive effect on the player's income. This represents the situation where surplus workers are available for recruitment.

However, large population size leads to the rapid resources consumption and environmental degradation. In contrast, population depression (below 25% of the total capacity[3]) will lead to economic loss which means the players' income rate will be reduced substantially. Below are summarized key characteristics and methods that can be used to manage PF in the region:

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[3] The total population capacity is referred to the game scenario where the population has grown to fill an entire population tab. However, population will continue to grow 'behind the scene' even beyond this point.

- PF increases automatically throughout the game and at the exponential rate. For example: once the total population reaches 500,000 the birth rate will be at 5 per second. However, when the total population reaches 900,000 the birth rate will be at 8 per second.

- By default, the larger population size will degrade the overall environmental condition at faster rate. This represents the real-world situation where the large population size contributes to the increasing pollution level and accelerating the resources extraction (e.g. Donohoe 2003). For example: once the PF has surpassed 30% of the total carrying capacity, the 'Environmental Factor' will be decreased (i.e. deteriorated) faster by 10%. Similarly, this effect will be magnified further in the larger population sizes.

- The population size can inhibit the maximum environmental factor capacity. For example, despite the players' attempts to improve the environmental factor (EF), EF capacity will not improve beyond 60% of its total capacity if the region is containing a large population size. This is to demonstrate the 'baseline, per-capita environmental emission' generated by each individual in the region.

- By sacrificing certain amount of wealth and emergency supplies, the players can use the 'Special Action' function to decrease the birth rate in the region. This represents an urgent governmental action for family planning programs. This action can be issued once every 15 minutes (in order to prevent overuse). Once used, this special action requires 15 minutes to 'recharge' before it could be reused again.

- Answering certain quizzes correctly helps reduce the population size (using the quiz game function). Some quizzes are about health and social issues. By solving these quizzes correctly, the players will be rewarded with minor population reduction bonus. This represents the players' direct actions to inform the population of problems that stemmed from the unsustainable population growth.

- Certain technological inventions and policies can be used to slow down the birth rate in the region. For example: by promoting and subsidizing the condom manufacturing, the region may experience the reduction in birth rate and unplanned pregnancies. Similarly, television programs can be tailored to broadcast subliminal messages about the population and social issues. This encourages the public to plan for the optimal family size (e.g. Jensen and Oster 2009). Also, television program can generate financial opportunity from advertisement at the same time (i.e. wealth bonus).

3.8.2.2 The environmental factor (EF):

The environmental factor (EF) is symbolized as plant leaves. The tab of this factor is highlighted in green color. EF represents the overall environmental condition in the region. It is the players' duty to maintain positive environmental condition in the region.

The players will lose the game should the environmental condition falls below the critical level (in this case, ~20% of the total environmental capacity). In other word, the players will lose the game even before the environmental condition in the region reaches 0%. This function is designed to simulate the situation where the environmental condition has degraded beyond the recovery threshold.

EF decreases gradually and automatically to reflect the environmental degradation caused by human activities. More importantly, Population factor (PF) can inhibit the maximum EF in the game (temporarily). For example: with the populace of 300,000 in the region, the EF cannot increase beyond 80% of its maximum capacity. Similarly, with the populace of 1,000,000 in the region, the EF cannot increase beyond 60% of its maximum capacity.

It is important that the players must devote attention, resources, and execute appropriate actions in order to maintain positive EF at all time. Below are the summarized key characteristics and methods that can be used to improve EF in the region:

- Increasing 'Population factor' will cause the EF to decrease at greater speeds (i.e. increase human population accelerates the environmental degradation).
- Players lose the game should the EF falls below 20%.
- Players can sacrifice certain amount of wealth in order to boost the EF. This 'Special Action' function represents an urgent political intervention to protect the natural environment from human activities (e.g. establishing a natural sanctuary / send in armed guards). This special action can be issued once every 25 minutes. Once used, the action needs some time to 'recharge' before it could be reused.
- Performing quizzes correctly helps improve the environmental condition in the region. Some quizzes (in the quiz mode) contain questionnaires about the environmental issues. By solving these quizzes correctly, the players will be rewarded with environmental points. The quiz represents the players' direct actions to inform the public of environmental problems and encourage them to participate in environmental conservation actions.

- Certain technological inventions and policies can be used to reduce environmental problems. For example: installing 'Grease Separator Module' in high-rise buildings can minimize some environmental problems by reduce the amount of solid waste and grease contamination in the sewage system. Another example is the 'Energy Conservation Policy' which penalizes the employees for not turning off computers and electrical appliances in office buildings when not in use.

3.8.2.3 The emergency supply factor (SF):

The emergency supply factor (SF) is symbolized as a carton box. The tab of this factor is highlighted in pink color. SF represents reserved supplies for the emergency uses (dried foods, bottled water, medical supplies, and other survival tools). As the government's front organization, TEC (the players' organization) is committed to support the government by distributing emergency supplies to those affected by the environmental and social disasters. These supplies are gradually withdrawn from the players' reserve automatically (in relation to the population size). It is important that the players maintain adequate stock of supplies in order to prepare for the unpredictable and disastrous events. The players lose the game should the supply stock reached 0%. Below are summarized of the key characteristics of this factor:

- Supplies will be withdrawn from the stock automatically and at regular intervals. Large population size will drain supplies faster than the smaller population size (represents the magnitude of population being affected by disasters).
- Apart from being withdrawn at regular intervals, large amount of SF will be withdrawn automatically during the event of major environmental and social disasters.
- The players will be rewarded with supplies after performing certain quizzes correctly. This represents the public supports by donating supplies for the players after the successful social development campaigns.
- Acquisition of manufacturing plants (i.e. factories) helps generate a small amount of supplies for the players over time.
- Players can boost the production of SF. However, wealth will be spent and the action will contribute to environmental degradation. Unlike the population and environmental special actions, the supply special action can be reactivated after a short period of time to represent the power of industrialization.
- Players lose the game when SF reaches 0%.

3.8.2.4 The wealth factor (WF):

Wealth factor (WF) is the last main factors in THE GROWTH. WF is represented by a unique currency symbol. The tab of this factor is highlighted in the dark blue color. WF represents the players' accumulated wealth (i.e. money). Similar to the real-world, wealth can be used for business investment and project funding.

The players can use wealth to fund the development of sustainable technology and policies. It can be used in business investment – to which the successful business ventures will generate profits back to the players over an extended period of time. Also, wealth is required to execute all types of 'Special Actions' (e.g. issue an urgent environmental protection programs, issue a rapid production of emergency supplies, or initiate the family planning programs). Below are the summarized of key characteristics for the wealth factor:

- Wealth is generated automatically from the players' assets. For example: Once an office building has been acquired, it will generate wealth (in the form of profits) back to the players throughout the game. Thus, multiple buildings and businesses will magnify the players' income rate.
- Wealth can be used to issue special actions. These actions can improve the environmental conditions, increase the supply production rate, and reduce the population growth.
- Wealth can be used to develop new technologies and implement new policies. In turn, these improvements bring various benefits to the region.
- Similar to supplies, certain amount of wealth will be withdrawn from the players' treasury automatically in the event of natural and social disasters.

3.8.3 Special Actions Function

'Special Actions' (SA) is a type of game function in THE GROWTH. SA represents the government's urgent political interventions. It allows the players to improve the environmental and social conditions in the region quickly. It also allows the players to produce large amount of supplies quickly.

To compensate for their usefulness, the special actions need to be 'recharged' once they have been invoked. In term of game mechanism, the special actions in THE GROWTH can be compared to the 'special abilities' mechanism found in many commercial games (e.g. call in reinforcements or cast a spell). There are three types of special actions in THE GROWTH. These being: 1) The population special action, 2) The environmental special action, and 3) The supply special action.

Figure 3.6: A set of Special Action GUIs: The supply special action (top), the environmental special action (lower left) and the population special action (lower right)

3.8.3.1 The population special action

This special action has a symbol of a family-of-five standing within a red-colored circular GUI. This family-of-five represents a relatively large family size (also see Guillebaud 2007, Newman 2010) and thus, the necessity to promote an optimal family size.

The population special action represents the government's effort to promote healthy family plans and social development programs to the public. For this, population special action can decrease population growth in the region. This special action can be invoked to decrease the population growth within its duration of effect. In exchange, this special action requires a generous amount of wealth and supplies to invoke. For example, the players need 100,000 points of wealth and 5,000 points of supply to invoke this special action. Also, to compensate for its usefulness, the population action needs 15 minutes to recharge once invoked.

3.8.3.2 The environmental special action

This special action has a symbol of trees standing within a green-colored circular GUI. Together, the trees and the green-colored GUI represent the natural habitats.

The environmental special action represents the government's urgent political intervention to restore the natural environment (e.g. the environmental reclamation projects or creating a natural reserve). Once invoked, this action improves the environmental condition within the region immediately. In exchange, this special action requires a generous amount of wealth. For example, the players need

200,000 points of wealth to invoke this special action. Environmental special action needs 25 minutes to recharge once invoked.

3.8.3.3 The supply special action

The portrait of this GUI is divided into four areas representing: purified water, energy, food crops, and healthcare / medicines. Together, they represent vital resources – especially during the disastrous events. The silver-blue color of this GUI emphasizes the fact that these resources are man-made and not of natural origin.

The supply special action represents the mass-production of goods to be used for the disaster relief programs. Examples of disasters in this game include industrial accidents, famine, disease outbreak, war, and natural disasters (e.g. earthquake, flood, and fire).

This action can be invoked to create a large amount of supply for the players' reserves immediately. In exchange, this special action requires a generous amount of wealth. This action also calls for a certain amount of environmental points (this represents the fact that industrial and manufacturing activities contribute negative impacts on the natural environment). For example: 80,000 wealth and 4,000 environmental points are required to produce 6,000 units of supply.

Unlike other special actions, the 'recharge time' for the supply action is relatively short which reflects humans' ability to extract the natural resources at rapid pace.

3.8.4 Quiz Function

Quiz function represents the players' direct campaigns to send the environmental and social messages to the public. Some of these campaigns encourage the public to act sustainably which contributes to the positive environmental outcomes in the region. Some campaigns encourage the public to donate the resources for the environmental and social development projects. Other campaigns encourage the public to plan for an optimal family size which resulted in the decrease of overall population growth in the region.

Figure 3.7: Quiz function can be accessed by selecting a grey 'eye' GUI located within the 'Special Action' tab

For many years, quiz has been used extensively in traditional classroom-based learning, paperboard games, and TV shows. Also, the quiz mechanism is being used as an element in some digital game-based learning (e.g. Brown n.d.; Erhel and Jamet 2013).

Quiz function in THE GROWTH can be linked to the 'Question-based Learning', an engaging activity that can be used in game-based learning (Prensky 2007: 161). Also, the random quiz sequence in THE GROWTH allows the same quiz question to re-appear for the subsequence occasions. This can be linked to the concept of 'Frequency of Repetition' and 'Reinforcement' as highlighted in the Hilgard's principles[4] (Knowles, Holton and Swanson 1998: 74). Similarly, Keller (2010: 47) has linked quiz with the 'Inquiry arousal' which could be used to promote the learners' curiosity and attention. For this reason, the quiz mechanism was adopted into THE GROWTH with

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[4] This is because the game expects players to spend considerable efforts and time with the quiz game function (in exchange for the in-game rewards). Also, the quiz questions that have already been answered by the players may re-appear later, allowing players to exercise their memories through 'overlearning' (e.g. Knowles, Holton and Swanson 1998: 74).

the aim to promote attention, promote motivation, and enhance environmental knowledge retention through overlearning.

Similar to quiz used in many other settings, the quiz function in THE GROWTH presents the players with questions where the players must find the correct answers for those questions. When the players initiated the quiz function, the game randomly picks up a quiz question from the pool consisted of more than 160 questions. Some of these quiz questions are concerning with the environmental issues. Other questions, however, are concerning with the technological, social, and health issues related to the growing population and the natural environment.

THE GROWTH uses the Knowledge of Result or KR (Dempsey, Driscoll and Sales 1993) to provide feedback to the players. KR method is selected for this project based on the suggestions from the studies that it can provide feedback for the players without the risk of distracting and overwhelming them with the extra information (e.g. Mory 2003: 753, Phye, Gugliemella and Sola 1976).

The game gives the result to the players immediately after they have chosen the answer. Players who have answered the question correctly will receive the messages such as "Correct!, +1000 wealth". On the other hand, players who have chosen the wrong answer will receive the messages such as "Try again!, -300 Environment". This technique aims to give the players with a perception of control as well as provide them with attributional feedback (Keller 2010: 52). Also, feedback in THE GROWTH is designed to be short and clear in order to prevent confusion and distraction.

Figure 3.8: Composition of a quiz function

The figure above shows the composition of a quiz function. At the top shows a small image which gives a small hint about the issue to the players[5]. At the center shows text-based information. Finally, there are three GUIs at the bottom: the green GUI with plant leaves symbol represents the environmental issue (or choice 1), the red GUI with a human symbol represents the social / health issue (or choice 2), and the blue GUI with a science symbol represents the technological issue (or choice 3). In the example case shows in the figure above, child slavery is considered as the social / health issues so the players who have selected the red GUI (or choice 2) will be rewarded with a minor population reduction bonus.

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[5] Some images are recycled and shared between different set of questions so players can not expected to rely on the images alone to solve the quiz problems.

Figure 3.9: A logical framework for the quiz function
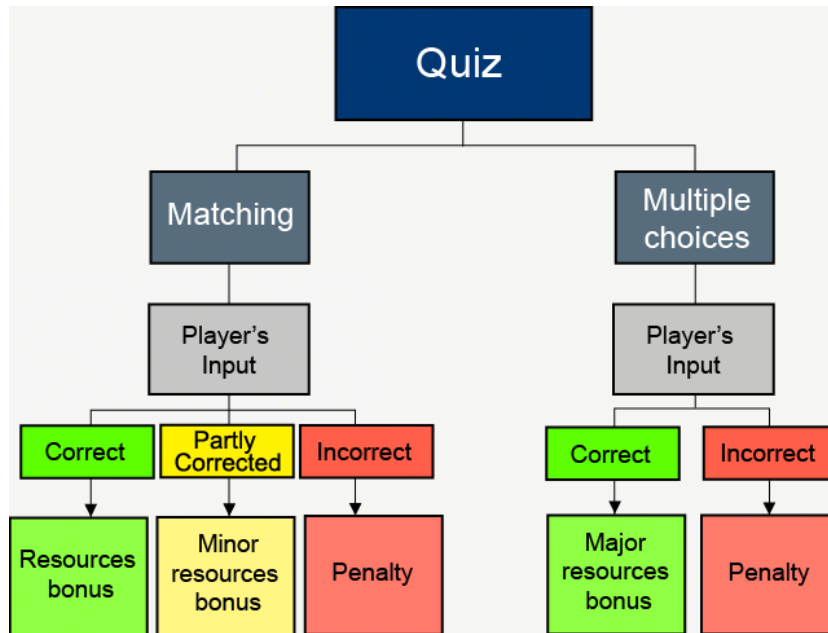
3.8.4.1 Matching Quiz

The quiz questions in THE GROWTH can be categorized into two types. The first type is the 'Matching Quiz'. These quiz questions present short articles to the players and ask them to match it with a corresponding issue (e.g. environmental issue, social / health issue, or technological issue). As some articles can be aligned to more than one issue, there may be more than one correct answer for these quizzes[6] (i.e. the second best answer).

An example of 'Matching Quiz' can be seen in the following scenario:

The game picks up an article about a recent police prosecution of a gang who abducted and forced the children into beggary. As this is considered as a crime / social issue, the players who have selected the red GUI (representing the social issues) will be rewarded with some population reduction bonus. This represents that the players have successfully promoted awareness on the social issues to the public.

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[6] For example, pesticide contamination in agricultural products can be considered as both the environmental and health problems at the same time.

3.8.4.2 Multiple-Choice Quiz

The second type of quiz is the 'Multiple-Choice Quiz'. These quiz questions ask players with a question while showing them three choices. For example, the game asks the players: "Which one is the correct projection of global human population in 2015?" Three possible answers are: 1) Two billion, 2) Five billion, and 3) More than seven billion. To this end, the players who have selected the third choice will be rewarded with a minor population reduction bonus for answering the quiz correctly.

Due to their greater level of difficulty, rewards from the 'Multiple-Choice Quizzes' are generally greater when compared to rewards from the 'Matching Quiz'.

3.8.5 The upgrade function

Upgrades represent campaigns, policies, and technologies that the players can utilize in order to bring the beneficial effects into the region. Examples of these beneficial effects include:

- Decrease the population growth rate. For example: 'Advanced contraceptive devices' & 'Family planning program' upgrades.
- Decrease the occurrence of man-made and environmental disasters. For example: 'Conflict reduction program' (decrease armed conflicts and wars), 'Disease prevention program', and 'Safety protocol' upgrades.
- Improve the overall environmental condition in the region. For example: 'Forest conservation program', 'Marine protection program', 'Networked public transportation system', and 'Recycle' upgrades.
- Increase the supply productivity. For example: 'Automated precision production system' & 'Food waste-to-animal feed' upgrades.
- Increase the long-termed environmental & financial gains through advanced sustainable technologies. For example: 'Solar cooker devices', 'Water efficient system', and 'Sustainable energy storage system' upgrades.

Figure 3.10: An upgrade interface shows a selection of upgrades available in the game. The first row from the left: 1) Invasive species eradication program, 2) Natural conservation campaign, 3) Automated precision production system, and 4) Robotic workforce. The second row from the left: 1) Recycling program, 2) Real-time metering system, 3) Global population awareness campaign, and 4) Media for societal reformation campaign.

Upgrades with the green and brown color signify their association with the environmental aspect. Upgrades with the blue and green color signify their association with both the technological and the environmental aspects. Upgrades with the red color signify their association with the societal aspect.

Figure 3.11: Upgrade status – a small icon on the top left indicates the status of an upgrade. The green color represents a newly implemented upgrade / an upgrade that has more than 50% of its service lifetime. The yellow color represents an upgrade that has less than 50% of its service lifetime. The red color represents an upgrade that has fallen below 10% of its service lifetime – a warning sign that the players should consider re-investing in the upgrade in order to retain their beneficial effects.

Some upgrade items, however, increase / improve one game factor at the cost of another. For example, the 'Natural Habitat Restoration' upgrade improves the overall environmental condition in the region, but continuously drains a small amount of wealth and supplies from the players' treasury until the upgrade duration expires (representing the budgets necessary for the forest patrol and maintenance missions).

Each upgrade requires the initial funding from the players (in the form of wealth and supplies). The majority of upgrades in this game are based on the existing policies and technologies. Some upgrades, however, are based on the proposed policies and emerging technologies and only few are based on the impression of futuristic technologies. There are more than 70 upgrades in THE GROWTH.

In order to upgrade, the players select one of GUIs presented in the main upgrade interface. If the players have enough resources required for the upgrade, the game then takes resources from the players' treasury. The game now attempts to implement an upgrade for the players. This process can take as short as 3 minutes or as long as 20 minutes depending on the type of an upgrade.

There are chances that the upgrades may fail to be implemented. This represents the failure in technological research, the public rejection, or the political intervention. For example: 'No Plastic Bags Policy' (withdrawing plastic bags from all shopping centres) has a relatively low chance of successful implementation due to the strong resistant from both the business and the consumers. In an event of failure, the players' initial funding into an upgrade will be lost in the process. Chance of the success and failure vary from one upgrade to another.

In term of the game design, the game of chance can generate enjoyable experience as highlighted by Csikszentmihalyi (1992: 73). However, the setbacks should be 'experienced' by players in meaningful ways rather than 'punishing' them with harsh penalties, as proposed by Squire (2011: 144).

Once the players have successfully introduced a new upgrade to the region, it will contribute certain beneficial effect(s) to the region for a certain period of time. Once an upgrade has expired, the players will need to reinvest in an upgrade again in order to regain the beneficial effect(s).

Figure 3.12: The logical framework for the upgrade function
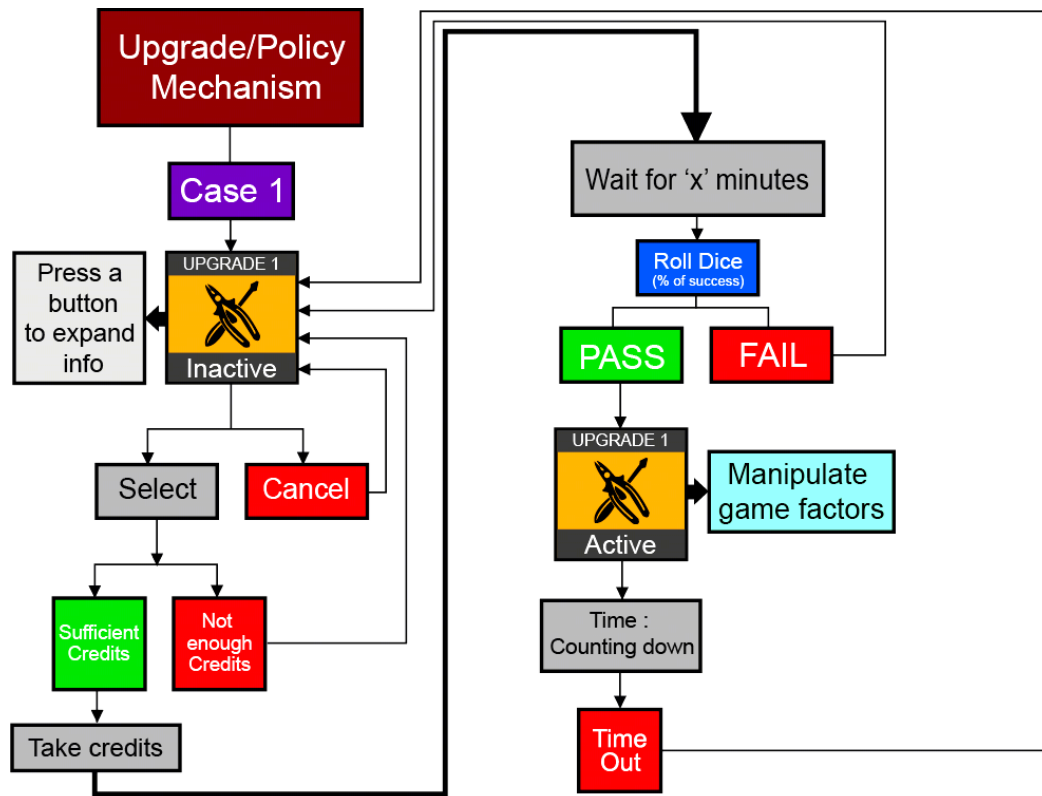
Figure 3.13: An expanded upgrade window showing a statistical description of the upgrade as well as the textual & graphical content.
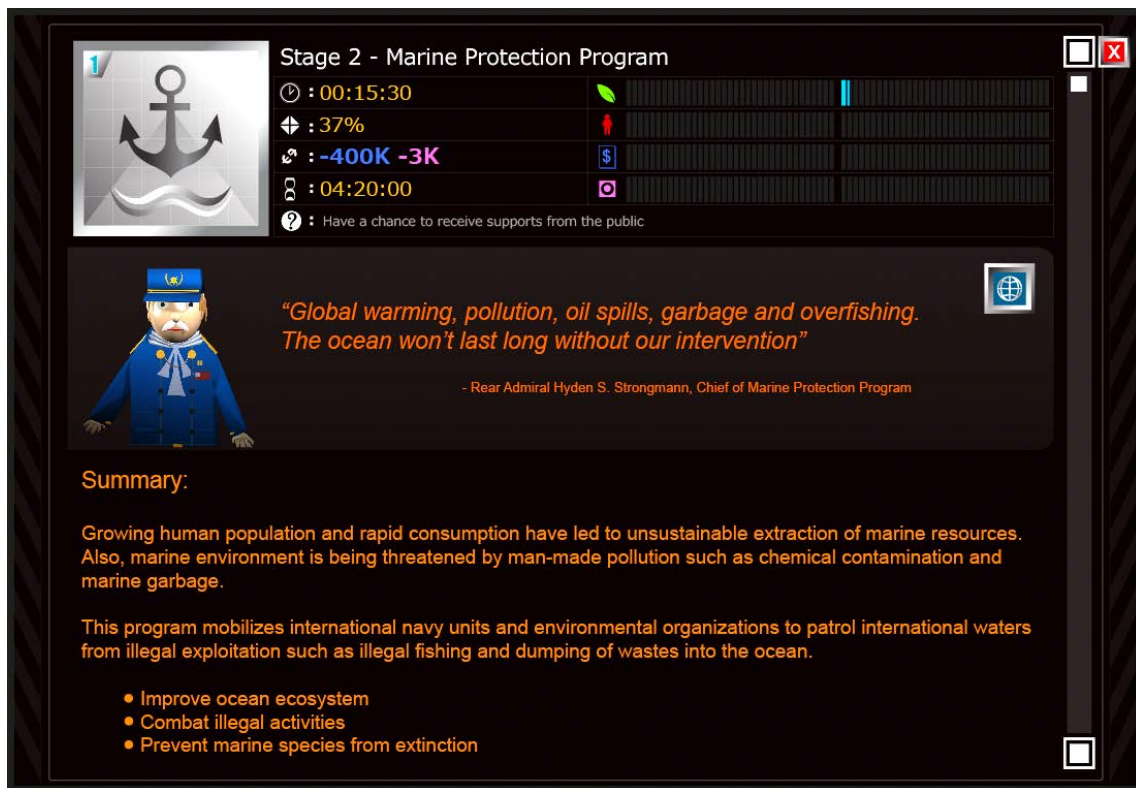
Figure 3.14: Components of the upgrade panel – A) The unique graphical representation for the selected upgrade item, B) The name of the upgrade item, C) The time required for the implementation / development, D) The success rate for the upgrade implementation (in percentage), E) The amount of resources required for this upgrade item, F) The time duration that the upgrade will stay active (i.e. the lifetime), G) Special notes about the upgrade (if any), and H) the bar chart showing beneficial / negative effects generated by this upgrade.
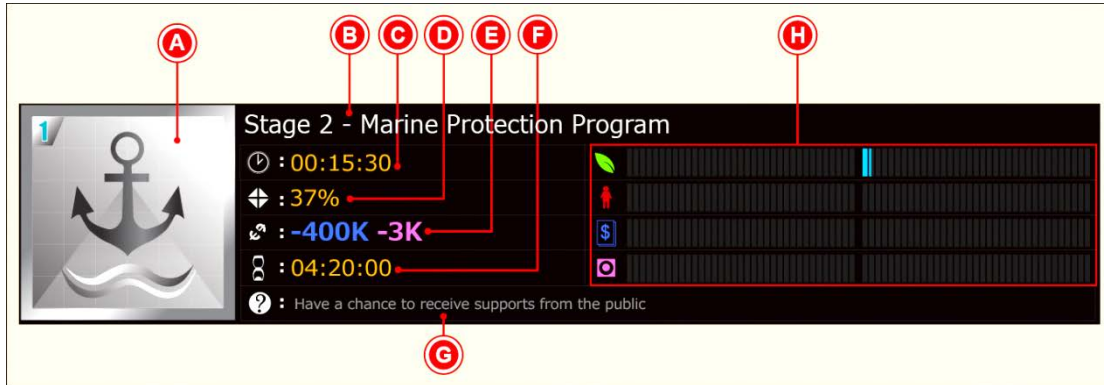
The players can expand an upgrade GUI into a full window which gives the players with detailed text-based information and statistical description about the upgrade (see the figure above).

The lower, scrollable section of the window provides text-based information about the upgrade. A large-size text written in quote-style aims to give 'quick information' to the players about the particular upgrade. This idea was inspired by Flesch (1948: 107) who has suggested that quotes, as a form of personal sentence could be used to promote the reader / user interests. Also, a small quantity of quotes in this game are written in 'humorous' and 'tongue-in-cheek' style aim to attract the players' curiosity (e.g. Keller 2010: 23). On the right side of the quote section is a 'trivia GUI' (blue GUI with the globe graphic) that gives the real-world information about the particular upgrade to the players (e.g. recent efforts on the marine conservation programs). Below is the 'summary' section aims to summarized the key concept of the particular upgrade. The summary section is followed by the 'full information' section (absent from the figure) aims to give a very descriptive and detailed information to the players.

Consider the figure above: It shows that the implementation of 'Stage 2 - Marine Protection Program' will take 15 minutes and 30 seconds to complete. The success rate for implementing this program is 37%. This upgrade requires 400,000 wealth points and 3,000 emergency supply points. For a successful implementation, this upgrade will provide some environmental points for the players for the duration of 4 hours and 20 minutes. While this upgrade is active, the player may receive financial supports from the public.

Upgrade types

Although not explicitly mentioned in the game, upgrades can be further categorized into three types which are: campaigns, policies, and technologies.

3.8.5.1 Campaign

Campaigns represent the government' appeals to the public in order to conserve the natural environment or to combat the social problems. For example, the 'Recycling Program' and the 'Water Conservation Program' are considered as campaigns since the government and the environmental organizations cannot enforce the public to participate in these programs directly. Since these campaigns are relied on strategic communication and public cooperation, they are generally inexpensive in cost and require a relatively short time for implementation when compared to technologies.

However, a number of campaigns have a relatively low-medium chance of successful implementation. In other word, the game implies that not everyone is willing to devote their time and finance, and efforts for the environmental and social causes. To this end, vigorous efforts must be made before the members of the public can be convinced to act sustainably and responsibly.

Further, beneficial effects from many campaigns are inconsistent. For example, the public may not be interested to partake in the recycle program during the first phase of the campaign (i.e. the first 10 minutes). Sometime after, however, the public may start to participate in the program – resulting in considerable improvements of overall environmental condition in the region. This inconsistent game bonus aims to highlight the unpredictable nature of human behaviours in the real-world. It also emphasizes the importance of the public cooperation[7].

3.8.5.2 Policy

The second upgrade type is policies. Policies represent strict guidelines that require members of the public to follow or risk facing negative reinforcements (i.e. penalty). The cost, time, and the success rate for policies varied from one to another.

For example, 'Resources Conservation Program' is a policy devised by the companies and requires that employees must turn-off electronic appliances in the office during lunchtime or risk facing the penalties. This policy has a relatively high chance to be successfully implemented because it is also

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[7] Harth, Leach and Kessler (2013) for example, have suggested that environmental participation from the in-group is an important motivator for environmental-friendly behaviours.

at the companies' interests to minimize their operational cost as well. To this end, the game suggests that people are more likely to mobilize their efforts to avoid penalties and other negative reinforcement.

On the other hand, an 'Environmental Tax' policy has a relatively low chance to be implemented successfully. This is because the policy also affects the price of many consumer products in the region, and thus, receives strong public and political oppositions.

3.8.5.3 Technology

The third upgrade type is technology. Technologies represent new inventions. They can be used to improve the environmental and social conditions in the region. Some technologies help reduce the operational cost and maximize the profits for the players as well. A number of advanced technologies in THE GROWTH are expensive in cost, require substantial amount of time to implement, and have a relatively lower chance of successful implementation when compared to campaigns and policy upgrades.

However, a number of technologies can contribute long-term benefits to the region. For example, the 'Water-efficient appliances' and 'Solar Cookers' can contribute positive environmental effects to the region over a long period of time. This implies that these technologies are mechanically stable, can be operated with minimum maintenance cost, and can be replicated easily.

Upgrade costs for technologies can vary from one to another. For example, the 'Smart Socket' technology (preventing phantom loads in electrical devices) is more financially affordable to develop and distribute to the market when compared to the wind and solar technology. Additionally, the smart socket technology can still provide high environmental benefits to the region by eliminating phantom loads from the thousands of households in the region.

3.8.6 The investment function

Investment function represents the players' acquisition of business in the region in order to expand his / her financial capacity and the sphere of influences. Acquired businesses are henceforth referred to as 'assets'. Additional income from these assets then can be used to fund the environmental and social development projects. Apart from the financial gains, some assets can provide the players with other beneficial effects as well (e.g. the 'Advanced Research Centre' can utilize frameworks to decrease the environmental and social problems in the region).

As mentioned earlier (and in the setting & storyline), THE GROWTH presents a situation where the humans can no longer afford to expand into the few remaining natural habitats. To this end, the only way for the players to expand their financial capacity is to 'takeover' assets from other businesses (via financial and political domination). There are more than 50 businesses in THE GROWTH covering environmental, social, and financial categories (e.g. a natural reserve, a high-rise apartment, and an organic food farm).

The 'Investment Function' is almost identical to the 'Upgrade function' in term of game mechanism. The only difference is that the players' owned assets can provide financial resources and beneficial effect(s) to the players for an indefinite amount of time throughout the game. In other word, assets will not expire.

Figure 3.15: An investment interface. Each portrait represents an asset that the players can 'takeover' from the original owners. Colored portraits represent assets that have already been acquired by the players while the grey portraits represent assets that have yet to be acquired.
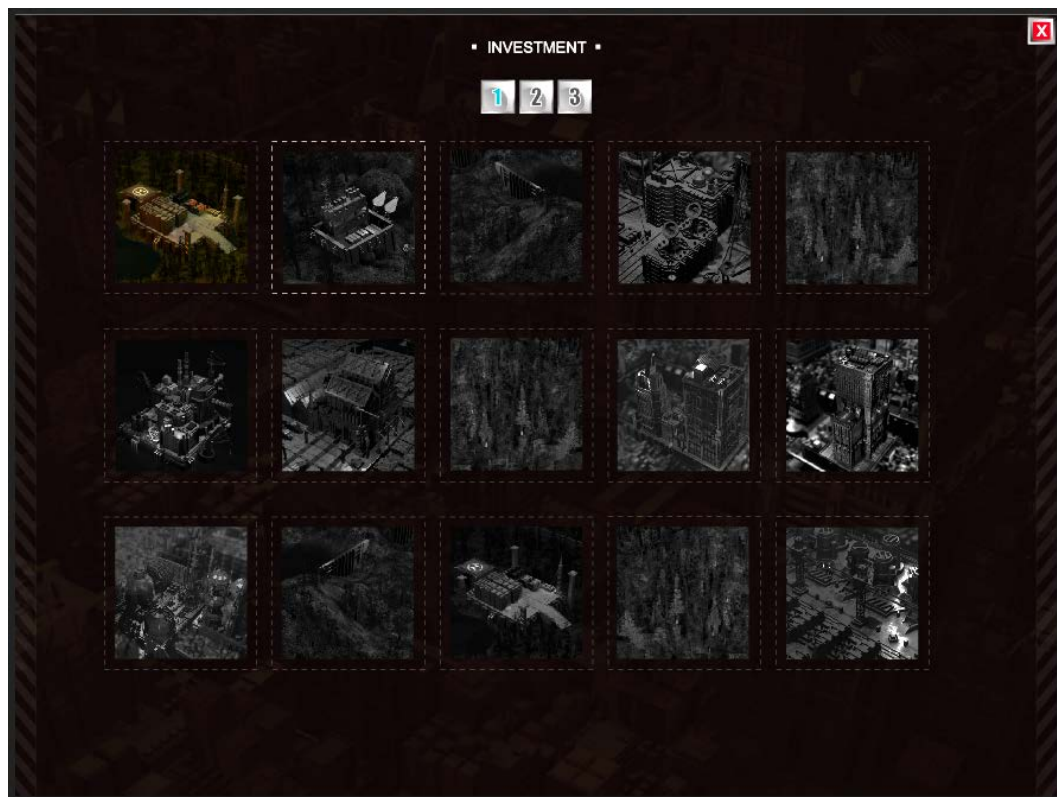
3.8.6.1 Asset customization

Asset customization is available in THE GROWTH. This feature highlights sustainable improvements and new technological devices that can be used to improve the acquired assets. For example: a newly acquired high-rise apartment building originally provides the players with 80 points of wealth per second. The players now have several options to customize this building such as:

- Install an anaerobic digester system (AD) on this apartment to reduce some emission outputs and generate the extra income for the players (from converting bio-wastes into the valuable fuel gas). Once installed, this building will provide players with the additional of 9 wealth and 2 environmental points per second.

- The players can install renewable energy technologies on this building to gain extra financial resources while improve the overall environmental condition in the region at the same time (by decreasing the consumption of non-renewable energy sources).

- The players can promote sustainable lifestyles in this apartment building. A successful promotion of sustainable lifestyle campaign will contribute some positive environmental effects to the region (this program has a relatively low-medium chance of success due to its dependent on the public cooperation).

- The players can initiate a space saving program to re-arrange the layout of this apartment complex – generating an extra income from renting out the free space (this program has a relatively low chance of success due to strong rejection from the apartment occupants).

Figure 3.16: Player's owned assets in THE GROWTH can be customized / improved further. The left pane shows four customization items available for a conserved forest. The right pane shows three customization items available for the wind energy farm.

Surveillance Robots

COST: 80,000 Wealth pts.
BENEFITS: +5 Environmental pts. / second
+2 Wealth pts. / second

COMMENTS: May crash (penalty to wealth pts)

Eco-tourism

COST: 14,000 Wealth pts.
BENEFITS: -

COMMENTS: May attract tourists
(inconsistent bonus to wealth
& environmental pts.)

Managed Hunting

COST: 15,000 Wealth pts.
BENEFITS: -

COMMENTS: May attract wealthy hunters
(Significant albeit inconsistent bonus to wealth, but
can also trigger anger from environmentalists)

Animal carcass trade

COST: 800 Wealth pts.
BENEFITS: +32 Wealth pts. / second

COMMENTS: Can also trigger anger from
environmentalists.

Improved turbine design

COST: 250,000 Wealth pts.
BENEFITS: +1 Environmental pts. / second
+30 Wealth pts. / second

COMMENTS: -

Sustainable Energy Storage System

COST: 800,000 Wealth pts.
BENEFITS: +6 Environmental pts. / second
+42 Wealth pts. / second

COMMENTS: -

Automated diagnostic system

COST: 170,000 Wealth pts.
BENEFITS: +8 Wealth pts. / second

COMMENTS: -

While many assets can generate the extra income and resources for the players, some assets such as the 'Protected Forests' and 'Wildlife Sanctuaries' will drain a constant amount of financial and supply resources from the players' treasury in exchange for the environmental points. For example, a protected forest provides 18 environmental points per second for the players. In turn, this forest requires 50 points of wealth per second to operate (e.g. the cost for the forest protection and maintenance).

Because of the significant benefits provided by these assets, each asset requires a substantial amount of initial investment. In other word, THE GROWTH was designed in the way that the players will

need to spend a considerable portion of their time gathering resources before they can acquire an asset (by vigorous performance on the quizzes).

The investment function can be linked to the 'long-term' goals and also require the players to develop their own objectives (e.g. Csikszentmihalyi 1992: 55)

3.8.7 Random Event Function

As mentioned earlier, several studies have highlighted the positive learning and motivational outcomes from incorporating the element of uncertainty and randomness into the learning materials (Csikszentmihalyi 1992: 73, Howard-Jones and Demetriou 2008).

In the learning context, the element of surprises can be a stimulating factor for the learners (Wlodkowski 1985: 51). In human biology, the element of surprises is also being linked to rewarding and dopamine released by the mid brain areas (Elliot, Friston and Dolan 2000). Additionally, studies have highlighted the positive learning outcomes from incorporating uncertainty into the games and game-like environment. For example: Howard-Jones and Demetriou (2008) have obtained positive results from their study groups which suggested that uncertainty may enhance the players' level of engagement with the game and recall ability. Similarly, Koster (2005: 116) has highlighted that unpredictability can promote engagement and learning. Malone (1980: 52) has suggested that the uncertainty can bring the challenge to games. Also, Keller (2010: 47) has suggested that unexpected change can trigger curiosity. However, some studies have highlighted the risk of negative impact from utilizing randomness and uncertainty in game environment due to their perceived association with the gambling activities (Howard-Jones and Demetriou 2008, Gibson 2011).

In THE GROWTH, the main aim for incorporating the random event function is to promote the players' awareness on the unpredictable nature of environmental and social situations. The random events are based on the environmental and social events that have occurred in the real-world. In THE GROWTH, events such as crimes, disease outbreaks, and disasters occur as the game progresses. There are more than 100 random events in THE GROWTH.

Figure 3.17: The positive random game event (left) and the negative random game event (right)

Figure 3.18: The expandable pop-up window informs the players about the event (accessible by selecting on the random event notification GUIs)
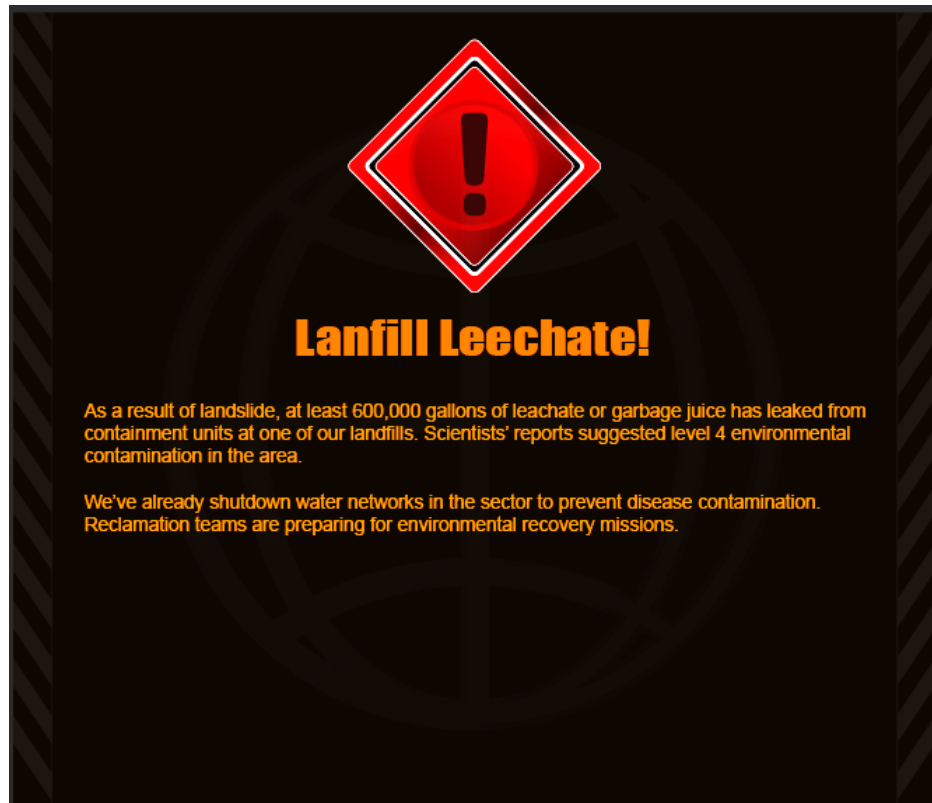
For example, an expanded random event window (in the figure above) informs the players of leachate that has been leaked from the containment units. The toxic liquid has seeped into the underground water channels, causing serious environmental problems. The incident also implicated health and well-being of the citizens in the affected area. This incident costs the players some environmental and wealth points (financial resources are required for the reclamation project as well as for sending in clean water to help citizens in the area).

By using certain campaigns, policies, and technologies, the occurrence of disasters such as disease outbreaks and armed conflicts can be reduced. However, the players have no influence over major disasters such as earthquakes and tornadoes.

On the other hand, the players can promote the occurrences of positive events in the region. For example: by introducing the 'Environmental Conservation Program' into the region, there are chances that the public will contribute their supports towards the environmental conservation projects.

The author acknowledged the limitation where the random events in the game are simulated with a simplified mathematical formula (instead of relying on the complex geographical features such as the meteorological factors). The random event function simply aims to highlight the 'causes-and-effects' to the players in relation to the real-world constrains. For example, there is a 30% chance for every 15 minutes that the population will donate financial supports for the players if the 'Natural Restoration Campaign' was invested (whereby the possibility of such event could be higher or lower in the real-world depending on other socio-political factors).

3.8.8 The time speed function

Figure 3.19: Time speed GUIs in the growth. Normal time speed (left) and 6x time speed (right)

The players can adjust game speed in THE GROWTH at any time by selecting a GUI. Once selected, the game is accelerated by 6 times of the normal game speed.

3.8.9 The save game function

The game session can be saved. However, the game allows for only one 'save game slot'. This means the old saved game session will be replaced automatically by the new save. This decision was made so that the players will have to plan and act carefully since they cannot go back into the past (or go back to a specific timeline in the past) in order to correct the mistakes or avoid the undesirable events (e.g. disasters).

3.9 THE GROWTH: Layers of learning activities

Figure 3.20: The layers of learning activities in THE GROWTH: Passive learning takes place in the form of game story and the educational content embedded within the game. The active learning takes place in the form of quiz where the players are pressured to comprehend and answer the quizzes actively in order to gain resources. Experiential learning occurs when the players interact with game factors / game objects in an attempt to influence upon the game environment.
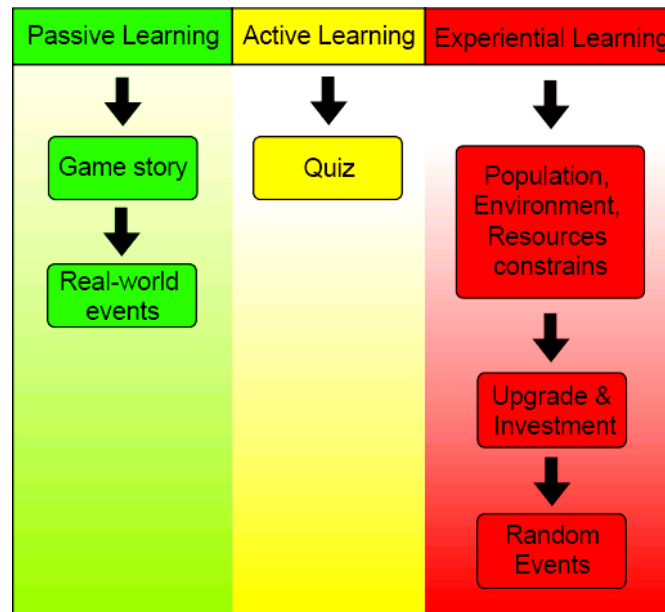
Learning activities in THE GROWTH can be decomposed into three levels which are: 1) passive learning (e.g. McFarland et al. 2013) 2) Active learning (e.g. California State University 2007) and 3) Experiential learning (e.g. Mayo 2007) (as shown in the figure above).

3.9.1 Passive learning

The passive learning element in THE GROWTH includes textual information in general such as the game story and descriptions of game objects. The textual information waits passively to be discovered by the players. This aspect is comparable to the story presented in many commercial

games where the players can choose to read or ignore the information[8]. It is designed to support the learning for intrinsically motivated players, and thus, may not be an efficient method by itself in the formal learning context.

Passive learning in THE GROWTH can also be linked to 'The Information Deficit Model' – a behavioural model which assumed that human behaviours can be changed when provided with the new / correct information (Tanenbaum, Antle, and Robinson 2013: 3389). While the textual information is arguably an essential element of the game, its ability alone to persuade the players towards the pro-environmental behaviours is highly questionable.

3.9.2 Active learning

On the other hand, the active learning element in THE GROWTH is presented as a quiz mechanism (which is arguably the core function of the game). The game mechanism 'pressures' the players to perform the quizzes in order to gain in-game resources so they can be used to prevent the game world from the total collapse (caused by overpopulation and environmental pollution). Thus, the quiz mechanism could be linked to 'The controlling aspect of rewards and communications' where the players are being pressed against game constrains (e.g. Ryan, Mims and Koestner 1983). Further, in-game resources gained by performing quizzes can be used to empower players' influence in the game world, and thus, can be linked to the concept of the 'performance-based assessment' as highlighted by Shute and Ventura (2013: 18).

3.9.3 Experiential learning

Experiential learning, on the other hand, provides knowledge and understanding to the players while they interact with the game itself. Experiential learning in THE GROWTH can be linked to what Claxton (1997: 22-23) has described as 'Learning by Osmosis' – the situation where a person is engaged with a complex activity without an explicit and structured set of instructions. In THE GROWTH, the players have to manage multiple variables such as the population, the environmental

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[8] For example, a combat simulator game may include a real-world description for each weapon (place of origin, year of service, cartridge type and capacity, weapon weight, and an effective range). Although it is unlikely that players need to know this information to be able to shoot a weapon in the game, the information would give players some advantages during the game if the game simulates these weapons' characteristic accurately (e.g. choosing light-weighted and mechanically stable weapons). If not, this information only serves the interested players who wish to learn the factual knowledge about weapons.

condition, and the resources at the same time without being instructed by the game. The players also have to plan ahead for the unforeseen events such as disasters.

More importantly, the players have to prioritize their resources constantly to match the game situations. The players will have to make decisions by themselves. Examples include: When to take a quiz? What kind of improvements is necessary for the current situation? What is the best time to invest the large amount of resources on the investments? How much resources should be produced and stockpiled for the emergency situations?

As mentioned earlier, the players have to plan their actions ahead as many policies and technological development would take a considerable amount of time to implement (the failures might occur). Some policies may generate a significant amount of income for the players at the expense of environmental degradation. Some policies can prevent certain disasters, but also require a constant and substantial amount of resources from the players. Often, the players have to rely on their own experiences in order to execute appropriate action(s). The game provides the players with only a basic feedback system such as a set of bar chart indicating situations in the city).

In behavioural models, the experiential learning in THE GROWTH is can be linked to 'The Procedural Rhetoric Model' where the knowledge is gained through the interaction with the complex game system (Tanenbaum, Antle, and Robinson 2013: 3390).

Because THE GROWTH incorporates the aspect of social factors (e.g. public donation and rejection on sustainable policies) it can also be linked to 'The Emergent Dialogue Model' where the members of the public are presented as stakeholders whose influences can dictate the success rate for environmental conservation projects (Tanenbaum, Antle, and Robinson 2013: 3391).

Figure 3.21: Different types of feedback in THE GROWTH. A) a notification GUI informs the players of the in-game events, B) a notification GUI informs the players of insufficient resources, C) a notification GUI informs the players of the change in game factors after using a special action, D) a notification GUI informs the players of the 'game over' condition, and E) three types of attributional feedback informing the players on their performance after answering a quiz question.

3.9.4 THE GROWTH: Aligning THE GROWTH to A Guidelines for Environmental Games (GEG)

The tables below are the comparison between THE GROWTH and the newly proposed Guidelines for Environmental Games (GEG). Tables highlighted in pink indicate the mismatch / incompatible issues between THE GROWTH and the GEG.

GEG Elements (Content aspect)	THE GROWTH
Moral obligation	Use quizzes, game stories, and random game events to highlight moral obligations (e.g. Improper waste disposal can expose children living near landfills to serious risks of health problems caused by the toxic pollution).
Financial incentives	Use game stories, game mechanism, and random game events to highlight the long-term financial benefits from the environmental conservation. Highlight the long-term financial benefits from investing in sustainable technologies (e.g. energy & water efficient appliances).
Reflection to the real-world	Quizzes and other textual contents in THE GROWTH are based on the real-world events.
Humour VS Instruction	Present both light humour and instruction statements in the form of quotes (a type of game story)
Technology & Limitation	Despite their usefulness, many advanced technologies in THE GROWTH are expensive and difficult to develop. Technological items such as robots can experience malfunction while wind and solar collectors can experience a sharp decrease in productivity due to meteorological factors.
Localization VS Global perspectives	About 50% of game contents are based on the environmental and social issues in Thailand (target location) while another 50% are based on the global issues.

Societal & health well-being	Use game stories, game mechanism, and random game events to highlight the importance of societal & health well-being.
Layers of information	Use the inverted-pyramid style to arrange game information (from the most important to the least important).
Narrative & support story	An elaborated support story is accessible to the players at any time.
Up to date	The game information is based on the recent real-world events.

GEG Elements (Mechanism aspect)	THE GROWTH
GUI (Graphical-User-Interface)	The players execute game actions through GUIs. Use GUIs to provide feedback to the players (e.g. inform the players of the current population level and environmental condition in the region).
Empowerment	Through careful actions, players can elevate environmental condition in the game. The game world can be transformed from 'a deteriorating region' into 'an environmentally stable region'. By taking over other businesses, the players gain access to additional sources of resources and other beneficial effects. Additionally, these businesses can be improved further to generate even more resources / beneficial effects.
Linearity	Non-linear sandbox game similar to city-management games such as SIMCITY and ANNO 2070.
Tutorial	The non-interactive tutorial describes basic game mechanism and can be accessed by the players at any time.

Dynamic elements	Several types of game dynamisms are presented. For example: 1) The population grows at exponential rates, 2) The high population density deteriorates the environmental condition and consumes the resources at accelerated rates, and 3) Disasters such as disease outbreaks and war can be partially prevented by players' actions. Due to the dynamic gameplay, players have to choose between the financial gains and the environmental benefits on several occasions. For example, restoring a conserved forest will improve overall environmental condition in the region, but require a constant amount of financial resources to maintain.
Information on demands	Except from the GUIs informing the players on game events, the current game version lacks this aspect. Players have to consult the tutorial on their own terms for the extra information.
Feedback	Use 'The knowledge of result' (KR) and attributional feedback to inform the players of their performances with the quiz game function. Several feedback types exist to inform the players about game status. For example: 1) Notify players about the game events, 2) Notify players that their requests cannot be completed due to insufficient resources, and 3) Notify players about the increase / decrease in game factors. Special effect (i.e. smog) and warning lights are used in the game scene to warn players of deteriorating environmental condition in the region.

| Difficulties & Complexity | The level of difficulty cannot be adjusted in the current game version.

NOTE: Self-report accounts have shown that many participants perceived THE GROWTH as 'challenging'. However, some participants have perceived the game as 'hard'. |
|---|---|
| Competition & Cooperation | The current game version does not support multiplayer gaming mode. |
| Goal(s) | Similar to SIMCITY games, THE GROWTH has no explicit goals. Players can still lose the game if the environmental condition in the region fell below the critical level (20%).

Players, however, can define their own goals such as: 1) Acquiring all assets available in the game and 2) Maintaining positive environmental condition in the region for a certain period of time.

Goals can be defined by the system and the educators in the future. |

GEG Elements (Representation aspect)	THE GROWTH
Neutrality	Use storyline and game mechanism to emphasize on the importance of environmental conservation based on the long-term economic incentives (e.g. eco-tourism and forest products), health and societal benefits (e.g. the effects of air pollution and water contamination on health issues), and the scientific values (e.g. development of bio-technology).
Genre	Role-play, sandbox strategy game (city-management)

2D / 3D	Used 2.5D graphics to render GUIs, and static images. This technique gives an impression of 3D graphics without significant implication on the computer performance. Used 3D graphics to render the scene (i.e. the region). NOTE: Due to participants' reception, the next iteration will shift from 3D to a fully 2.5D environment in order to facilitate versatility on laptop computer devices as well as reaching to players with low-medium grades computers.
Environmental storytelling	Make use of environmental story telling. For example: 1) Use yellowish and coarse textures to signify the effect of heavy pollution level in the region, 2) Visualize the differences between large & detailed buildings versus small impoverish buildings to signify social gaps, 3) Large buildings are surrounded by the security measures such as fences and watch towers to signify social insecurity, 4) Use smokes, chimneys, and heavy machineries to signify the pollution from human activities.
Fantasy VS Realistic	Use a partial-fantasy (an alternate timeline based on the Earth). Game contents are based on the real-world events. However, the setting, players' role, and graphical representations are based on the imaginary concept of a dystopian world.

3.10 THE GROWTH: Preliminary sessions

Preliminary sessions were conducted between early 2012 to August 2013. The objective of the preliminary sessions was to investigate key areas such as the participants' overall satisfaction with the game, motivation, and basic learning outcomes.

The snowballing sampling method (a type of non-probabilistic sampling method) was used to recruit the participants. This method was selected because the final experimentation will be conducted on a specific population group (Thai participants of 18-59 year of age). Also, the method was convenient for recruiting participants in a limited timeframe.

The total of seventeen (17) male participants of Thai nationality between 22-29 years old had voluntarily participated in preliminary sessions. These were: 11 post-graduate students based at Coventry University, 3 undergraduate students (based in Thailand) and 3 office employees with post-graduate degree (also based in Thailand).

All 11 post-graduate students from the Coventry University were contacted directly (face-to-face) by the researcher in the UK. This is the first group to participate in preliminary test sessions. The other six participants were first contacted by agents of the researcher in Thailand and, after receiving participants' confirmation, the researcher contacted them again via both the telephone and e-mails in order to arrange for date and time. All six participants in this group did not have any contact with the researcher prior to their recruitment. The preliminary sessions with this second group were conducted in Bangkok (Thailand).

All participants have reported they have prior experience with the computer and / or paperboard games beforehand. In regards to computer games, five participants have identified themselves as avid gamers, while another 12 identified themselves as casual gamers. As this project aims to deliver a game from single-player perspective, all sessions were conducted with one participant at the time. All sessions have been conducted at the participants' choice of locations.

The preliminary sessions were heavily relied on physical equipment such as paper cards which were used as 'mock-ups' to represent the concepts of the digital version. A laptop computer and online timer software were used to assist the gameplay. A dice was used to produce randomness and uncertainty during the session. Each session was completed within approximately 70 minutes.

A 5-point Likert-style rating scale (Saunder et al. 2007) was employed to obtain players' level of satisfaction with the game in term of: 1) Learning game rules, 2) The theme & graphical representation, and 3) Game mechanism.

A semi-structured interview was employed to investigate further about players' game experiences and knowledge gains. The latter was measured by the single post-test method where participants were asked to recall the topics highlighted in the game. Transcripts were analyzed using the thematic analysis. Thematic analysis was selected for its flexibility, opportunity to gain insights from the information, and relatively quick in term of execution (Braun and Clarke 2006). All of the preliminary sessions were conducted in Thai language (participants' and the researcher's native language).

Each session started with the researcher welcoming a participant to the study, followed by approximately five minutes of informal discussion in order to establish an acquaintance with the participant. The researcher then started the actual session with a formal introduction of the project. Participants were told that they were recruited to help evaluate the concept of a game project and that their opinions would contribute to the future development. This statement aims to raise participants' level of confidence as they were asked to 'evaluating' the concept of the project rather than being 'subjected' to an experiment itself.

In all sessions, the participants were encouraged by the researcher to produce comments and to criticize the project freely.

3.10.1 THE GROWTH: Preliminary results

The majority of participants did not experience difficulties in learning game mechanism. This is probably because all participants have had experiences with game mechanism prior to the session. However, several participants have reported / and or expressed degrees of distraction mainly because of the multiple pieces of physical materials and equipment were utilized during the preliminary sessions.

The majority of participants also commented on the graphics and visual design of the game positively. One participant commented on the printed graphic that "I really like these [static images from the game]. They look good, but have a disturb feeling about them". Another participant commented that "I like the artwork and I wish you make this into the real game". Additionally, role-playing element and the neutral representation in THE GROWTH were appreciated by some participants. One participant noted that: "I like the way there are many things you can do to help the

planet". In another account, a participant noted that "The content is rich ... I also like the way [the game is] more about science, saving money and quality of life ... less about just save cute animals".

In term of motivation, 16/17 participants have reported that their main motivation was to learn about new technologies and actions that can be taken to reduce personal energy consumption. This suggests that participants were motivated mainly by financial benefits offered by new technologies.

10/17 participants have shown their strong interests in the social issues highlighted by the game. A participant noted that "I feel sorry for the new generation. People care only for themselves these days". Another participant noted about the poverty issue highlighted in the game that "I know a family with four small children and they don't look so good. I mean they wear dirty clothes, [they] look so skinny and beg for the living". Yet another participant commented that "Just like the old saying, more kids make you poor".

Some participants have expressed their interests to review all the cards even after game sessions in order to learn more about contents that they might have missed during the sessions. In one account, a participant noted that "I know about solar panels, but I've never imagined using the sun [solar energy] for cooking!" In another account, a participant noted about the solar tower technology presented in the game as followings: "That's nice, so even the desert can be used to produce energy"

Cutting personal expenditures and other financial benefits offered by the technology seems to be the top priority for almost all participants while the co-benefits on the environment seem to be acknowledged to a lesser degree or not at all. This holds true for both the UK-based and Thailand-based participants. Energy (gas and electricity) seems to be a popular topic amongst participants, possibly due to much higher electrical consumption (and cost) when compared to water.

The transportation topic received good attentions from the participants as well. Already, public transportation is the primary choice of travel for 12 participants. However, the participants have commented that the public transportation in the country should be improved. A participant noted that "I want our government to improve the transport system. We should have more buses and lanes for buses".

15/17 participants admitted that they are unlikely to pay the premium price for environmental-friendly products such as food. However, participants are willing to invest on energy and water efficient products in order to save utility cost in the long run. Interestingly, 8 participants reported that they would welcome tax imposed on unsustainable products (e.g. carbon tax), but only if the policy in question is applied to everyone. According to several participants, the real-world factors

also play an important role in participants' commitments to environmental causes. One participant noted that "I've been separating recyclable from [municipal] waste for many years, but garbage collectors seem to mix and crush everything altogether in the truck so I'm not sure if the government is still working on this [recycling] or not". In turn, this statement was corresponded to an expert's report of inefficient waste management system in the country (Thairath 2014). Inconsistencies between learning context and the real-world implementation were noted by Knowles, Holton and Swanson (1998: 107-108). Another participant cited the lack of recycle bins in his area as the reason to stop recycling. On another account, a participant noted that "I separate my wastes so I can give them [recyclable waste] to [a] waste buyer[9] for free as a good gesture".

In term of the learning outcomes, Knowledge gains were measured by the participants' ability to recall and describe articles from the session verbally. All participants were able to recall and discuss articles from the cards (highest = 8/10, mean = 5.7/10, lowest =2/10)[10]. Energy saving and emerging technologies were most recalled topics. Deforestation and illegal encroachment were also topics of interest to them (possibly due to recent reports of government's mass prosecution of illegal loggers and encroachment on natural habitats earlier this year). Unplanned pregnancies and crimes were topics most recalled by participants in social category.

There was no noticeable difference in the knowledge gains between the avid-gaming and the casual-gaming participants. However, office workers and UK-based students have demonstrated the greater ability to recall articles from the game. This is possibly due to an increased awareness through their responsibility over the utility bills and other living expenditures (which are considerably more expensive when compared to the electrical and water rates in Thailand).

However, results from the preliminary sessions suffered several limitations. Firstly, the number of participants attending preliminary session was too small to make a meaningful generalization. Secondly, the preliminary sessions' results were obtained by the post-test only method. This means

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[9] Waste buyers are common in many areas of Bangkok. These merchants visit houses and buy any recyclable materials. In turn, recyclable materials are sold to private recycling stations.

[10] The recall rates for the preliminary session participants were slightly higher compared to the results from both the experimental and the control group in the main study. Additionally, the preliminary session participants were exposed to THE GROWTH prototype (alpha version) which can be considered as an 'inferior' learning medium when compared to both THE GROWTH (V.1.0) and the reading material (for the control group) used in the main study. To this end, it should be noted that the preliminary session participants' higher recall rates might be attributed to the fact that the follow-up interview questions were administered by the researcher during the interview allowed them to reflectively recalled more topics than they should originally had. This flaw in the research design was rectified in the main study.

the researcher is unable to establish whether the positive learning outcomes were the resulted from the participants' previous exposure to other environmental information or the game itself.

Thirdly, the preliminary session participants' relatively higher topic recall rates (when compared to the participants from the main study) might be attributed to the flaw in the research design itself where the follow-up questions administered by the researcher during the interview might have artificially allowed the participants to reflectively recall more topics during the interview than they should have had on their own (this flaw was eventually rectified in the main study).

3.11 Conclusion

This chapter discussed the design and the game mechanisms of THE GROWTH: a prototype environmental game with a special focus on the unsustainable growth of human population. The development of THE GROWTH was guided by the newly proposed Guideline for Environmental Game (GEG) as well as the participants' feedback during the preliminary sessions. In turn, the creation of GEG was inspired by a number of learning, motivational, and game theories as discussed in the previous chapter.

The design of THE GROWTH has been discussed lengthy in this chapter. THE GROWTH aims to address and teach the players about environmental issues caused by the rapid population growth and the unsustainable use of resources. The possible solutions that could be used to restore the ecological balance and to improve social and health well-being of the populace were offered in this game (e.g. family planning, sustainable technologies, social policies, eco-policies, and public cooperation). The benefits and the shortcomings of each solution were highlighted in the game through the use of textual information, graphical information, and game mechanism. Unpredictable events (e.g. natural disasters, the shift in economic landscapes, and the social disturbances) can make appearances in the game – altering the gameplay dynamically and allow the players to experience the possible outcomes of their actions. THE GROWTH encourages the players to use multiple solutions and apply them to each situation accordingly.

Overall, the participants appeared to satisfy with the game design during the preliminary sessions (i.e. the mock-up design). Participants' feedback during the early development stage helped the researcher in highlighting a number of shortcomings of the game design and the experimental design itself. These issues were rectified in the actual experimental sessions.

The next chapter will discuss the methodology and procedures used in the main experimental sessions.

4. Methodology

4.1 Introduction

This chapter starts with the discussion on the hypotheses of this research. The chapter then discusses the methodologies used in this research including the rationale and the protocol used during the recruitment of participants, the apparatuses used, the experimental design and the procedures.

As the research questions are focused on the learning and motivational outcomes, the conclusive outputs from the participants are required. This can be achieved by using the "Multi-Strategy Design" (Robson 2011: 167) – allowing the analysis and interpretation of both the quantitative data (e.g. memory and factual knowledge test) and the qualitative data (e.g. the reflective thinking) in the same study.

Towards the end of this chapter the researcher discusses the methods used in the analysis of the quantitative and the qualitative data obtained from the participants.

4.2 The hypotheses

As mentioned previously in the literature review chapter, researchers may have different viewpoints when it comes to utilizing game-based learning platforms in education. Some studies claimed that game-based learning platforms can enhance learning outcomes (e.g. Gee 2003, Arslan et al. 2011) while others have reserved opinions on the subject (e.g. Egenfeldt-Nielsen 2007, Squire et al. 2005).

For this study, the researcher developed a prototype environmental game based on the learning, the motivational, and the persuasion theories. The following are hypotheses that will be tested in this study (H_N designates the null hypothesis and H_1 designates the alternative hypothesis respectively):

4.2.1 The difference in knowledge outcome between the participants who use the game and the participants who use the reading material (based on a set of multiple-choice questions)

H_N: There is no difference in knowledge outcome between the two learning groups on average

H_1: The two learning groups have different learning outcome on average

4.2.2 The difference in the time spent on the task and the post-test outcome (based on a set of multiple-choice questions)

H_N: The amount of time spent on the task does not influence the post-test outcome on average

H_1: The amount of time spent on the task influences the post-test outcome on average

4.2.3 The difference in knowledge outcome between the male and the female participants (based on a set of multiple-choice questions)

H_N: There is no difference in knowledge outcome between the male and the female participants on average

H_1: The two groups have different learning outcome on average

4.2.4 The difference in knowledge outcome between age groups (based on a set of multiple-choice questions)

H_N: There is no difference in knowledge outcome between age groups on average

H_1: Age groups have different learning outcome on average

4.2.5 The difference in feedback on the learning mediums

H_N: There is no difference in feedback on the learning mediums between the experimental and the control group on average

H_1: The two groups have different feedback on the learning mediums on average

4.2.6 The difference in responses towards the concept of pollution tax[1] between the experimental and the control group

H_N: There is no difference in responses towards the concept of environmental tax between the two groups on average

H_1: The two groups have different responses towards the concept of environmental tax on average

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[1] The pollution tax is an environmental conservation policy. This policy allows the government to impose a tax on non-environmental-friendly commercial products. For example, the price of imported foods will be more expensive owing to the environmental impacts involved in the packaging and the long-distant transportation. Agreeing with the concept of environmental tax means the participants are willing to sacrifice their financial resource so that it could be used for environmental recovery process.

4.3 Participant recruitment

In order to measure the learning efficacy of the prototype environmental game, participants are recruited to undergo the experimentation. Participants' based-knowledge will be compared to the knowledge they have gained after using the game / reading material. Additionally, participants' reflective thinking on the environmental and social issues will be measured. For this, the criteria for participant recruitment in this study are:

- Male and female participants native to Thailand. The restriction on nationality was chosen because both learning mediums used in this study was designed with a special focus to address environmental and social issues in Thailand.
- The ability to read / speak Thai language.
- Participants must be 18-50 year-of-age. To conform to the ethical standard, participants must be at least 18 year-of-age. The reason for excluding participants of older age (50+), on the other hand, was due to the assumption that older population group were not of what Prensky (2001) referred to as "Digital Natives" (although some of them might be what Prensky (2001) referred to as "Digital Immigrants"). Thus, a digital game and a reading material designed based on the digital game used in this study might not be a viable learning option for the older age groups.
- Although the required educational background is not specified for the recruitment (due to the possible risk of aversion / alienation), it is assumed that participants from these age ranges would possess at least a high-school-level educational background with basic computing skills[2].

The recruitment procedure of this study did not exclude physically handicapped individuals to participate (except for blindness). However, no participant had reported their disability or required special attentions from the researcher during the sessions.

There are two participant recruitment phases for this study. The first recruitment phase was carried out from February - May 2013 while the second recruitment phase was carried out from August - November 2014 (please refer to the figure 4.1 for additional information).

To carry out participant recruitments, electronic mails with basic descriptions about the research have been sent to distribution groups in Bangkok (Thailand) during both recruitment phases. The

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[2] Because of 'the random assignment design' of this study, the participants did not know about their assigned groups prior to the experimental session. The computing skills-related questions were not asked until the final part of the experimental session to prevent confusion / aversion. Further, to avoid discrimination, the researchers planned to accept participants with little / no computing skills (although their results will be excluded from the main analysis for integrity reasons). However, no participant assigned to the experimental group requires special attentions from the researchers on computing supports.

title: 'a conceptual plan for environmental information' was used instead of mentioning about the game or the reading material explicitly. This approach is an attempt to contain the effects of social interaction threats associate with multiple-study-group design (e.g. Trochim 2006).

The incentive (a snack pack) with the value of £2.50 was offered to all participants as tokens of gratitude for their time and efforts in this study. The incentive was not mentioned to the participants until the end of each session.

To reduce the bias issue associated with the sampling, people who might be familiar with the aims and goals of the study were excluded from the recruitment (e.g. family members, friends, and colleagues). At the end, this process produced the total of 82 participants[3] who had been voluntarily recruited in Bangkok by the process of purposive sampling method. The purposive sampling method was used so that suitable participants for this study (e.g. nationality, physical fitness, and desirable age ranges) may be recruited into the experimental session. Thus, the participants in this study did not represent the general population as per the rationale of probability sampling methods.

Provided with the participants' contact information, the researcher had made brief contacts with prospect participants prior to the main experimental session in order to confirm their participation and arrange suitable date and time with them.

After the confirmation with all participants (about a week prior to the first session), participants were given identification numbers by the researcher (e.g. #P1, #P2). After this, participants were randomly assigned into either the experimental group (i.e. the game group) or the control group (i.e. the reading group). The randomization process was executed digitally with the 'Research Randomizer' – a free-to-use online randomization package (Urbaniak and Plous 2008). The 'Blocked Design' method was used to allocate participants into each group evenly.

4.3.1 Participant demographic

The figure below shows a distribution table (by the participants' IDs). The upper block represents the first experimental phase and the lower block represents the second experimental phase respectively. Participants were allocated into either the experimental or the control condition via the process of 'blocked random assignment'. Light green boxes represent male participants while

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[3] More than 100 participants had originally signed-up to this study. However, many participants have declined to respond or participate due to personal reasons. This leaves only the total of 82 participants for this study (40 from the first phase and 42 from the second phase).

dark green boxes represent female participants. Red dots beneath the boxes represent participants who did not partake or did not complete the interview process[4] fully.

Figure 4.1: IDs of the participants after being allocated into the experimental and the control group. 70 male and 12 female participants have participated in this study (35 male and 6 female participants in each study group).

Figure 4.2: Participants' age demographic
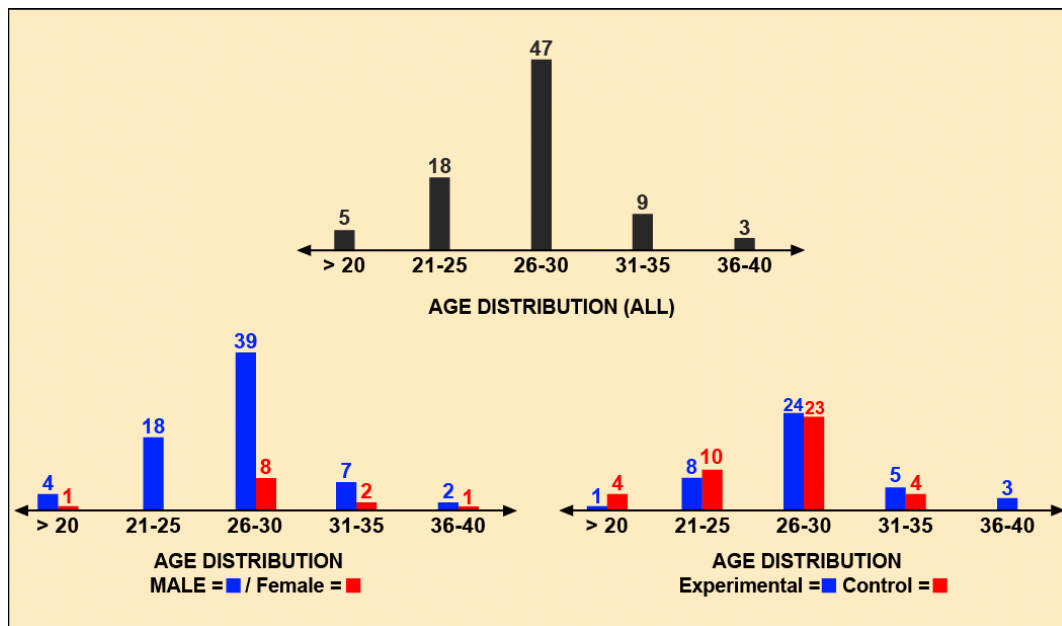
Participants of 26-30 year-of-age dominated this study (N=47) followed by 21-25 (N=18), 31-35 (N=9), 18-20 (N=5), and 36-40 (N=3) respectively as shown in figure 4.2.

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[4] The interview is the last step in each experimental session. The details of the interview are presented in the later section of this chapter.

As indicated in the figure above, there was a significant gender imbalance in this study as the total female participation accounted for only 17.14% of the total male participation. However, age distribution spread more evenly when consider the arrangement by study groups.

As indicated in the figure above, 21 participants (12 from the experimental group and 9 from the control group) did not partake / complete the semi-structure interviews due to personal reasons. This mortality accounted for about 25.6% of all participants in this study. Also, this mortality was not remarkably differed between both study groups (29.2% for the experimental and 21.9% for the control group).

4.3.2 Participants' gaming activity

Figure 4.3: Participants' gaming activity
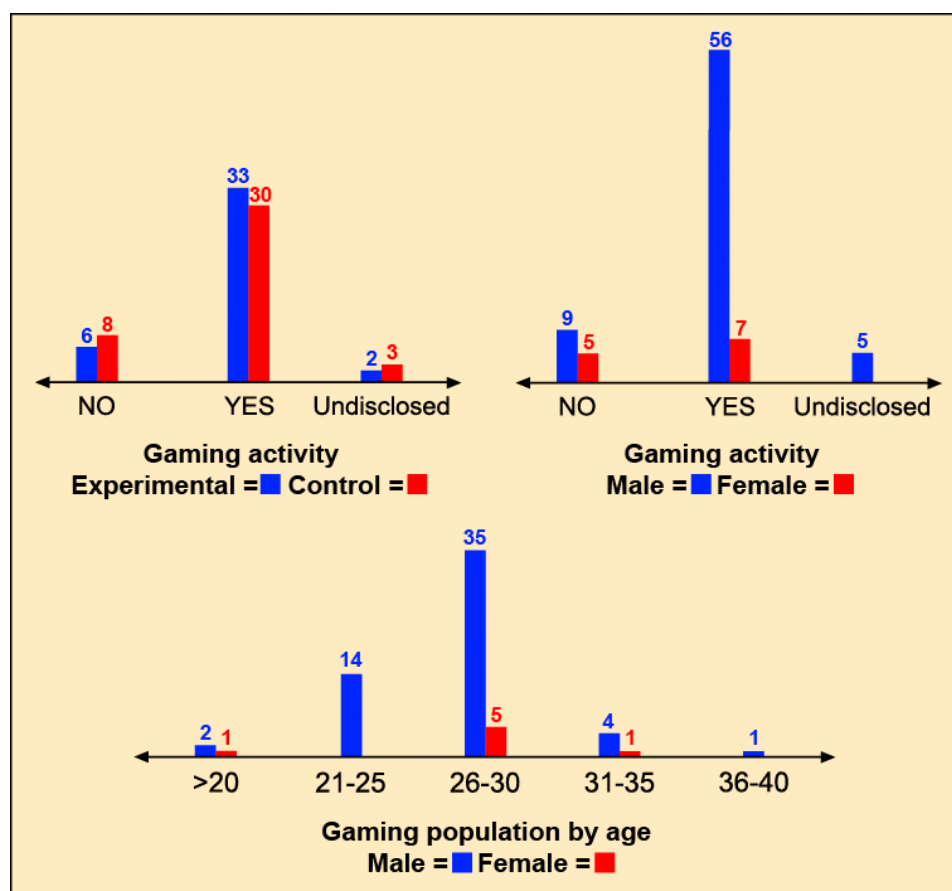
Participants were asked if they play digital games (any game genres) on the daily basis. As shown in the figure above, the majority of participants from both the experimental and the control group reported that they play games on the daily basis (80.49% for the experimental and 73.17% for the control group respectively). As indicated by the figure, the difference in the frequency distribution was not remarkably differed between the experimental and the control group.

As shown in the gaming activity comparison between gender groups, more male participants have reported to play game(s) on the daily basis when compared to the female participants (80% of male playing game(s) on daily basis compared to 58.33% of female participants).

In the arrangement by age group, it appears that more participants from younger age groups are engaging in gaming activity on the daily basis when compared to participants from older age groups. The distribution can also be summarised in percentage as shown in the table 4.1 below:

Table 4.1: Participants' gaming activity compared by age and gender groups

Age Group	No. of gaming participants	Gaming participants (in %)	Male gaming participants (in %)	Female gaming participants (in %)
18-20	3/5	60%	40%	100%
21-25	14/18	77.78%	77.78%	N/A
26-30	40/47	85.11%	89.74%	62.50%
31-35	5/9	55.56%	57.14%	50%
36-40	1/3	33.33%	33.33%	N/A

4.3.3 Locations

Figure 4.4: Self-reported accounts from the participants show their distribution on the map of Bangkok city. The legends to the right indicate participants' density in each district of Bangkok city.
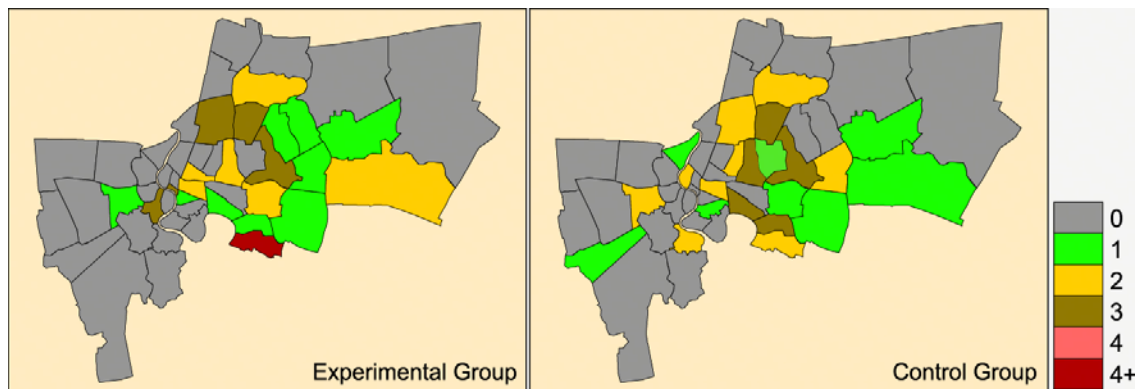
As shown in the figure above, self-reported accounts from the participants indicated that they were procured from different areas of Bangkok. Further, some participants have indirectly revealed during the interview that they were originated from or used to live in the countryside areas.

4.4 Apparatus / Materials

4.4.1 Experimental group

The following apparatus / material were used during experimental sessions (for the experimental group):

- A 14-inch high-powered laptop computer with THE GROWTH game and a video recorder software installed (the video recording software was used for game observation purpose)
- A mobile phone (used by the researcher as a silent timer / voice recorder)
- A consent form (paper-based)
- A laptop computer (researcher's use for organize purposes)
- A pre- and post-test forms (paper-based; 23 questions for each test)
- A QUIS survey form (paper-based; to investigate usability and software acceptance aspects)
- A supplemental survey form (paper-based; to collect additional information)

4.4.2 Control group

The following apparatus / material were used during experimental sessions (for the control group):

- A reading material – a book which contains identical textual and graphical information to THE GROWTH game (minus interactivity)
- A mobile phone (used by the researcher as a silent timer / voice recorder)
- A consent form (paper-based)
- A laptop computer (researcher's use for organize purposes)
- A pre- and post-test forms (paper-based; 23 questions for each test)
- A reading experience survey form (paper-based; modified from the QUIS survey form used in the experimental group)
- A supplemental survey form (paper-based; to collect additional information)

4.5 Procedures

Experimental sessions of the first phase were carried out with 40 participants from 23rd April 2013 – 10th May 2013. Experimental sessions of the second phase were carried out with 42 participants from 11nd November – 28th November 2014 (please also referred to figure 4.1).

All sessions have been conducted individually. This decision was made based on the following reasons: 1) THE GROWTH was designed as a single-player game while the reading material was designed to be read by one participant at a time, 2) The learning outcomes might be contaminated in group learning, and 3) Group discussion might inhibit some participants from expressing their statements during the interview Robson (2011: 294).

After the confirmation from participants, the process of random assignment (i.e. randomly assign participants into either the experimental or the control group) was conducted in each phase.

The majority of experimental sessions (61/82; 74.39%) had been carried out at the researcher's office in Bangkok (Thailand). The office location is situated in Sathorn road – a major commercial district in Bangkok. The office is within a short walking distance from Bangkok sky train network. The room used for conduct experimental sessions was about 10 x 6 meters. This air-conditioned room was shielded from ambient noises from the outside and equipped with standard office furniture (e.g. a long table, some chairs, and power sockets). Depended on their choice of transports, participants had been compensated financially by the researcher to cover their travel costs.

Due to logistical and personal difficulties, some participants have requested for alternate locations to be arranged for the experimental sessions (21/82 participants or 25.61%).

This means the standard experimental setting was not applied to all participants. Although alternate locations were relatively shielded from external distractions, the variety of experimental settings might influence the outcomes of each experimental session. However, these alternate locations could also provide an interesting opportunity to measure the outcome differences when compare results obtained from alternate locations to the standard experimental setting.

4.5.1 The experimental design & components

Figure 4.5: The chronological experimental procedures for the experimental group and the control group). Please note two differences between the experimental and the control group: 1) Their assignment to the learning medium and 2) QUIS survey was administered to the experimental group to understand their perception about the game while the 'Reading Experience Questionnaire' survey was administered to the control group to understand their perception about the reading material.
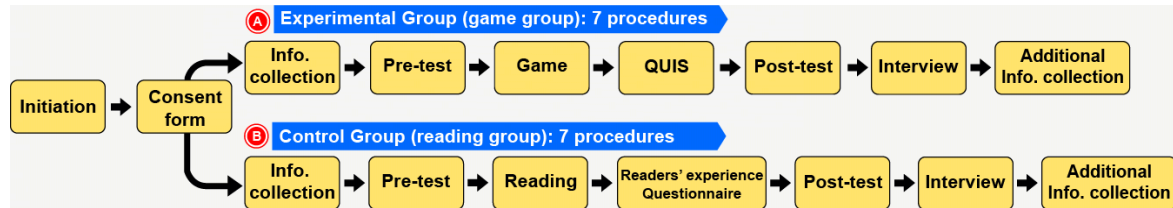
4.5.1.1 The initiation procedure

With group allocation completed prior to the meeting (i.e. the experimental session), the researcher welcomed each participant into his / her respective session. The researcher then spent about five (5) minutes prior to the main session to establish acquaintance with each participant.

Participants assigned into the experimental group were told that they were recruited to test a game prototype – a work in progress rather than a finished product. The researcher would be grateful for any comments about the game and the experimental session itself. This statement aimed to lessen the participants' negative emotional factors such as anxiety and the perceptions of being subjected to the test. On the other hand, this statement encourages the participants to 'criticize' the game and the experimental session freely.

On the other hand, participants assigned into the control group were told that they were recruited to test the concept of a book – a work in progress rather than a finished product. Similar to the experimental group, the participants were told that the researcher would be grateful for any comments about the book and the experimental session itself.

4.5.1.2 The consent form

All participants were asked to sign a consent form. The consent form for this study was adapted (with permission) from the consent form used by Dr. Fotis Liarokapis for the SIMAULA project at The Coventry University.

4.5.1.3 The pre-test

The measure of possible changes in knowledge outcomes was necessary for the learning aspect of both learning mediums (see Denholm 2014). For this, the pre-test consisted of 23 environmental and well-being questions (19 multiple-choice & 4 true-false statement questions) was administered to all participants in order to determine participants' base-knowledge on the environmental and well-being issues.

One point would be rewarded for each question answered correctly. Unanswered questions would be counted as incorrect answers[5].

Some of these questions have been inspired by the work of Coyle (2005) and Thai Office of Natural Resources and Environmental Policy and Planning (2012) among others. Some of the answers to these questions, however, have been adjusted to maintain the scientific accuracy informed by recent information derived from studies ascribed in the literature review section (i.e. up-to-date). The questions covered a wide range of environmental and well-being topics from both the national and global level (Please see Appendix 10 for the list of questions and answers).

4.5.1.4A THE GROWTH (for the experimental group)

After the pre-test, participants of the experimental group were asked to play the game. The researcher had spent about three minutes at the start of the game in order to give participants with a quick overview on game functions. For this, the researcher opened the 'tutorial function' GUI within the game and guided the participants from the tutorial pages instead of guiding them from the actual game screen.

Other game contexts (e.g. the nature of the game as the growing population game and the relationship between environmental and growing population in the game) were not mentioned by the researcher to prevent biases / knowledge contamination.

The questions / answers to the pre-test were contained within THE GROWTH's quiz game function (albeit in different wordings to test participants' level of comprehension). Correct answers can be revealed through participants' interaction with the game. Due to the random sequence of the quiz, all of the answers to the quiz may or may not reveal themselves in a given session.

The participants were told that the researcher expected them to use the game for at least 15 minutes, but they can also choose to stop the session whenever they like. Participants, however, can continue to use the game beyond the first 15 minutes as the maximum time restriction was

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[5] Unanswered questionnaires accounted for only about 0.69% of the total answers in the pre-test and then about 0.42% in the post-test.

not imposed in all experimental sessions. Coupled with the recorded game observation, the extended period of time that participants spent on the game may indicate the level of engagement[6]. Additionally, clocks were removed from the room to allow the participants to focus on the task without being distracted by the indication of time.

Once the participants informed the researcher to stop the game, the game phase stopped and moved on to the next phase (QUIS survey).

4.5.1.4B the reading activity (for the control group)

On the other hand, participants from the control group were assigned to use 'the reading material' – an A4-size printed book (high-quality, laser-prints on white matte papers). The reading material contains similar textual and graphical information to THE GROWTH (minus interactivity).

To assist browsing, 'thumb indexes' (small pieces of paper hanged from pages) were used to separate one chapter from another. It was also included to enable and encourage the participants to switch from one chapter to another with relative ease (also to mimic the fast content browsing ability in the digital game). There are four chapters in total. These being:

- The fast facts chapter (the 1st chapter): contains similar information to the quiz game mechanism in THE GROWTH. In a similar way that the game quiz function of THE GROWTH contains questions / answers from the pre-test, the fast facts chapter of the reading material also contains pre- and post-test questions (in random sequences, but within the first nine pages). As with the experimental group, the wordings had been rephrased from the pre-test to test the participants' level of comprehension.
- The storyline chapter (the 2nd chapter): equivalent to the storyline function of the game that introduces participants to this game world.
- The upgrade chapter (the 3rd chapter): equivalent to the upgrade function of the game.
- The investment chapter (the 4th chapter): equivalent to the investment function of the game.

As with the experimental group, participants from the control group were briefed for about three minutes on different chapters contained within the book. As with the experimental group, the context (e.g. the environmental context in the book and the relationship between environmental and growing population) were not mentioned by the researcher to prevent knowledge contamination.

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[6] Efforts have been made to detect and differentiate the 'signs of struggle' (i.e. confusion with the game mechanism) from the actual 'game activities'.

Participants were told that they were not required to read through each chapter in a chronological order. Also, participants were told that they were expected to read 'the reading material' for at least 15 minutes, but they can also choose to stop whenever they like.

Similar to the experimental group, the control group participants can continue with the reading activity beyond the first 15 minutes. Unlike the experimental group, however, recorded observation cannot be carried out for the control group (as the practice can be highly invasive), the extended period of time that the participants spent on the reading material may at least indicate the level of engagement with the learning medium. As with the experimental group, the indication of time (e.g. clocks) was removed from the room to avoid distraction.

4.5.1.5A QUIS

Questionnaire for User Interaction Satisfaction was administered to the experimental group participants once they have finished with the game. This survey form was used to understand quantitatively about participants' reception towards the game.

4.5.1.5B Readers' Satisfaction Questionnaire

Adapted from the QUIS, this survey questionnaire was administered to the control group participants once they have finished the reading activity. It was used to understand quantitatively about the participants' reception towards the reading material.

4.5.1.6 The post-test

Using an identical set of questions presented in the pre-test, the aim of the post-test is to detect participants' change in knowledge outcomes after being exposed to their respective learning medium.

4.5.1.7 The interview

All participants were asked to recall the topics that they might have remembered from their respective learning medium. The follow-up questions were used to understand participants' viewpoints on each topic recalled. In some instances, the follow-up questions were used to indicate the participants' attitudes towards the environmental, social, and technological issues.

4.5.1.8 The personal information collection

All participants were asked to complete a personal information form (e.g. age, gender, job description, level of income, and educational level). Additionally, a separate personal information form asking participants on their gaming activity was introduced by the end of each session

(partly to prevent confusion and other undesirable social interaction effects inclusive to the control group participants).

4.5.2 Experimental design: ANCOVA

As mentioned earlier, the pre- and post-test randomized experimental design (ANCOVA) was used in this study. This design allows the researcher to compare changes in knowledge outcomes before and after using the learning mediums.

Limitations of this approach, however, have been noted by some researchers. Colosi and Dunifon (2006) have noted extra time, exhaustion of participants' energy, and participants' awareness / aversion of being tested, among others. Trochim (2006), on the other hand, has noted the effect of 'social interaction threats' as limitations for multi-group test designs (e.g. control group participants might be disappointed when discovered that s/he weren't recruited into the experimental group).

However, as the pre- and post-test of this study were based on objective questionnaires, the pre-test of this study is resisted to the 'response shift' effect (Colosi and Dunifon 2006). Also, a strategy was implemented to alleviate the effect of 'social interaction threats' although this study accepts that the risk cannot be eliminated completely (please see the initiation procedure section).

4.5.3 Experimental design: The Multi-Strategy Design

Apart from ANCOVA, this study used 'Multi-Strategy Design' – combining both quantitative and qualitative approach (Robson 2011: 17). Robson (2011: 167) has highlighted the key benefits of using the multi-strategy design in research. These benefits include the ability to improve the integrity of research findings and the ability to use both methods to answer multiple research questions in a more comprehensive way. Kuperman (2009), for example, has combined systematic observations with participant inquiry during the debriefing of a fishing dispute game – producing both statistical results and the meaning of participants' game actions. Arslan et al. (2011), on the other hand, have used observation to obtain some quantitative learning outcomes between participants groups while group discussion was also used to obtain qualitative feedback from the participants such as reflection on the environmental game design. Additionally, Squire (2011: 113-130) has used the combination of observation and interviews to investigate participants' learning process.

4.6 Linking experimental design to the research questions

4.6.1 The first research question

The first research question asked: "Can a single-player digital game be an appropriate and attractive learning application for the players to gain insight about the relationship between the growing human population and the environmental issues?"

The 'appropriateness' of using the game in the education context can be measured by the knowledge outcomes. By using a set of close-ended multiple choices questionnaire, the researcher would be able to measure quantitatively on the participants' changes in knowledge outcomes. On the other hand, the semi-structure interview could be used in which the participants will be requested to recall and describe the environmental and social issues presented in their learning mediums. This allows the researcher to understand qualitatively about the participants' understanding of the environmental and social issues presented in the learning mediums. The benefits of using a semi-structured interview (as an open-ended interview) were highlighted by Yin (2011: 135) – chiefly allowing the participants to present the results from their viewpoints freely (also see Berg 2001: 70). The interview can be considered as an enhancement to the close-ended factual knowledge measurement.

The aspect of 'attractiveness' of the learning mediums (subjective opinions), on the other hand, can be measured by using the survey (quantitative method) and engage with participants in the interview (qualitative method). Further, the amount of time that the participants have spent on their assigned learning mediums (i.e. time-on-task) can be measured to determine their level of engagement with the task.

4.6.2 The second research question

The second research question asked: "How can we design environmental games for the players to gain insights about the relationship between the growing human population and the environmental issues via playing a game?"

As discussed earlier, this research question is concerned with identifying game components that could be useful in the environmental learning context. In order to answer this research question, the game sessions (played by the participants) along with the participants' verbal statements (obtained during the interview) will be recorded and the data analysed.

4.6.3 The third research question

Finally, the third research question asked: "What are the obstacles preventing the players from adapting environmental knowledge obtained from the learning mediums into the real-life?"

Based on the topics recalled by the participants, the researcher can administer follow-up questions as 'probes' to investigate participants' perceived intentions towards pro-environmental behaviours. This can be used to understand how the participants perceive the environmental issues around them and the reasons behind their resistance towards pro-environmental behaviours. The evidence then could be useful for the development direction of future environmental games.

4.7 The methodology for result analysis

The analysis was carried out to report and discuss the results obtained from this research. As mentioned earlier, the main research questions of this project involved data gathering in both quantitative and qualitative forms (the multi-strategy design). Qualitative data can be derived from the variety of participants' responses and behavioural intentions towards the environmental and social issues presented in the game / reading material.

Quantitative data, on the other hand, can be derived from: 1) The change in knowledge outcomes between study groups after using their respective learning mediums, 2) participants' reception towards their respective learning mediums, 3) The amount of environmental, social, and technological topics recalled, and 4) The frequency distribution of the top 5 topics in each category as recalled by all participants.

4.7.1 Analysis of the pre- and post-test scores

As mentioned earlier, the pre- and post-test were administered to all participants. The knowledge outcomes (i.e. scores) from the pre- and post-test can inform the overall changes in participants' factual knowledge on the environmental and social issues.

Calculation can be made by subtracting the 'post-test scores' from the 'pre-test scores' for each participant. Effects of knowledge changes then can be observed. The comparison then can be made by comparing the result between the experimental group participants to the control group participants. This process can be expressed by the following formulae:

$$I = (E_2 - E_1) \text{ minus } (C_2 - C_1)$$

Where E_2 = post-test scores from the experimental group, E_1 = pre-test scores from the experimental group, C_2 = post-test scores from the control group, and C_1 = pre-test scores from the control group.

Finally, the two-factor repeated analysis of variance (i.e. two-way repeated ANOVA), the independent t-test, and the Pearson's product-moment correlation coefficient (Pearson's r) were used where appropriate to compare statistical results between participants.

4.7.2 Analysis of the QUIS (Experimental group only)

Questionnaire for User Interaction Satisfaction (QUIS) is a set of survey questionnaire used to investigate the participants' interaction and experience with THE GROWTH game. For this, QUIS was administered exclusively to participants in the experimental group. The researcher aims to use the results of this survey for:

- Understand quantitatively about participants' reception towards THE GROWTH game by observing the rating scale. The outcome can inform not only the participants' opinions toward the game itself, but can also highlight advantage and shortcoming of the newly proposed Guideline for Environmental Game (GEG) since the game was developed around this newly proposed guideline.
- Comparing the results with the 'Readers' satisfaction survey' introduced to the control group where appropriate (see below). For example: participants' self-report level of stimulation on the task can be compared between the experimental and the control group.

4.7.3 Analysis of the 'Readers' satisfaction survey' (Control group)

Similar to the QUIS survey used for the experimental group, the readers' satisfaction survey is a set of survey questionnaire aimed to investigate quantitatively about the control group participants' perception towards the reading material.

The design of this survey questionnaire was based on the QUIS. However, questions dealing with interactivity were discounted as these were irrelevant to the control group.

4.7.4 Analysis of the recorded gameplay (Experimental group)

Experimental condition participants were informed that their activities on the screen may or may not be recorded anonymously for the analysis purpose. Recorded gameplay – as a type of observation can be used as complementary data to reinforce both the qualitative (e.g. Yin 2011: 9) and quantitative findings of this project. Due to the time constraints imposed on this project, the use of recorded gameplay was limited to basic observations such as: observing the participants' overall gaming performance and detecting difficulties in system learning.

4.7.5 Analysis of the semi-structured interview

The content analysis (CA) was used to analyse the participants' responses. The semi-structured interview took place after participants have completed their game / reading activity. As informed by (Berg 2001: 240) the process of content analysis was conducted as the following:

1) Converting participants' responses into written transcripts. Efforts have been taken to preserve participants' original meaning during the process of translation from Thai (participants' native language) to English.

2) Immersed into participants' accounts in order to familiarize with the written transcripts. Notes and codes were developed to categorize the data. Participants' perception and behavioural intention towards environmental / social issues were aligned and explained with the 'patterns of behaviours' as described by (Center for Alternative Technology 2010: 149-159).

3) The focus was paid to the analysis and identification of the manifest content, although latent content (hidden meaning) was also included into the analysis where appropriate. Patterns of results were then presented based on relationship and commonality basis.

4.8 Conclusion

In this chapter the researcher has presented the hypotheses, the experimental design, and the procedures used in this study. As discussed, the rigorous experimental design and procedures were deployed to ensure the validity of the findings. Additionally, the experimental design and the methodology for analysis were based on the necessity to use both the quantitative and the qualitative method to answer the three research questions adequately.

5. Findings

5.1 Introduction

This chapter presents the findings obtained from the participants during the experimental sessions (as discussed in the previous chapter). The findings presented in this chapter will answer the three research questions and provide evidence to the hypotheses raised in the previous chapter.

As discussed in the previous chapter, the test of knowledge in this study was primarily based on the 23 multiple-choice environmental and social questions where the participants' scores will be compared statistically (e.g. score comparison between study group, genders, and age).

Additional tests of knowledge outcome included the interview sessions where the participants' ability to recall and discuss / describe the environmental and social issues presented in their respective learning mediums were determined (i.e. the amount of environmental and social issues recalled and the ability to discuss / describe the said issues correctly). Thus, the test of environmental and social knowledge will provide evidence for the first research question (the use of a serious game as an appropriate environmental and social learning device).

Regarding of the design of an engaging serious environmental and social game (research question 2), the amount of time that the participants spent on the task (i.e. time-on-task) can be used to indicate the level of engagement with the learning medium – with longer time spent on the task could pronounce the higher level of engagement. Additionally, the QUIS survey and the interview accounts used in the study could provide feedback on each aspect of the game.

Interview accounts emerged from the interview sessions may contain participants' opinions on the real-world environmental and social issues. These opinions are valuable because they reveal the variety of how the participants reflect on the environmental and social issues around them (e.g. blame the industry and the government or refuse to participate in sustainable actions based on limited time and financial resource). This part of the finding provides evidence for the third research question (what are the obstacles that prevent the players from adapting environment concepts from games into the real-life?). It represents a leap from the learning activity to the real-world actions.

5.2 The hypotheses and the findings

5.2.1 The difference in knowledge outcome between the participants who use the game and the participants who use the reading material (based on a set of multiple-choice questions)

H_N: **There is no difference in knowledge outcome between the two learning groups on average**

H_1: **The two learning groups have different learning outcome on average**

As mentioned in the methodology and procedures chapter, a set of 23 environmental and social questions was used in both the pre- and the post-test to measure the participants' factual knowledge outcomes before and after using the learning mediums. One score point was allocated for each question answered correctly. Thus, there was no risk of score bias from the researcher as there was only one correct answer for each question.

Figure 5.1: The pre- and post-test score comparison between the experimental (using the game) and the control group (using the reading material).
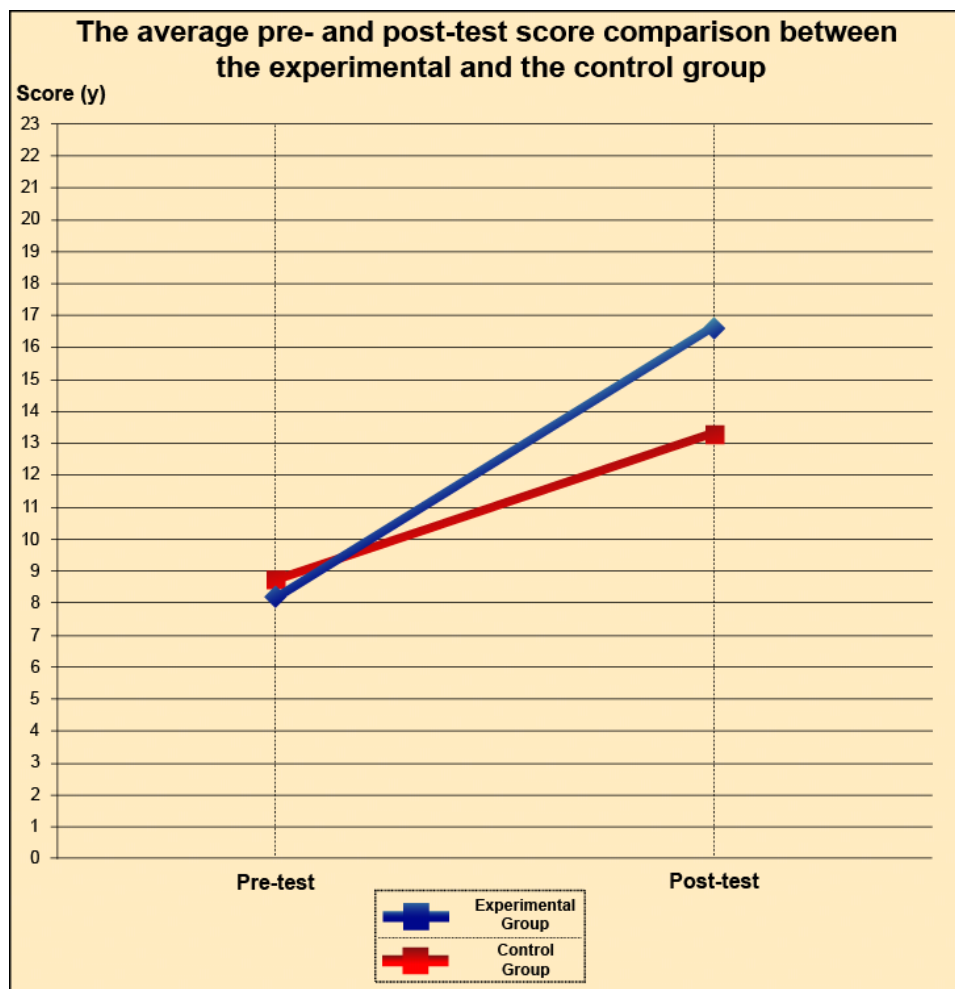
The result from two-way repeated measures ANOVA has shown a statistically significant difference in knowledge attainment between groups; $F(1,78) = 43.86$, $p = 0.006$ – indicating that THE GROWTH has a greater learning effect when compared to the reading material. Based on the findings, this study rejects H_N in favor of H_1.

5.2.2 The difference in the time spent on the task and the post-test outcome (based on a set of multiple-choice questions)

H_N**: The amount of time spent on the task does not influence the post-test outcome on average**

H_1**: The amount of time spent on the task influences the post-test outcome on average**

The time that participants spent on their respective learning mediums (time-on-task) was measured to investigate whether the longer time spent on the learning mediums could indicate the higher post-test score or not[1].

Figure 5.2: The scatterplot showing the relationship between the time-on-task and the post-test score for participants of the experimental and the control group. The regression analysis suggests a weak correlation between time spent on task and the post-test score outcomes for both study groups ($r = 0.2753$ / $p > 0.05$ for the experimental group and $r = 0.1015$ / $p > 0.05$ for the control group).

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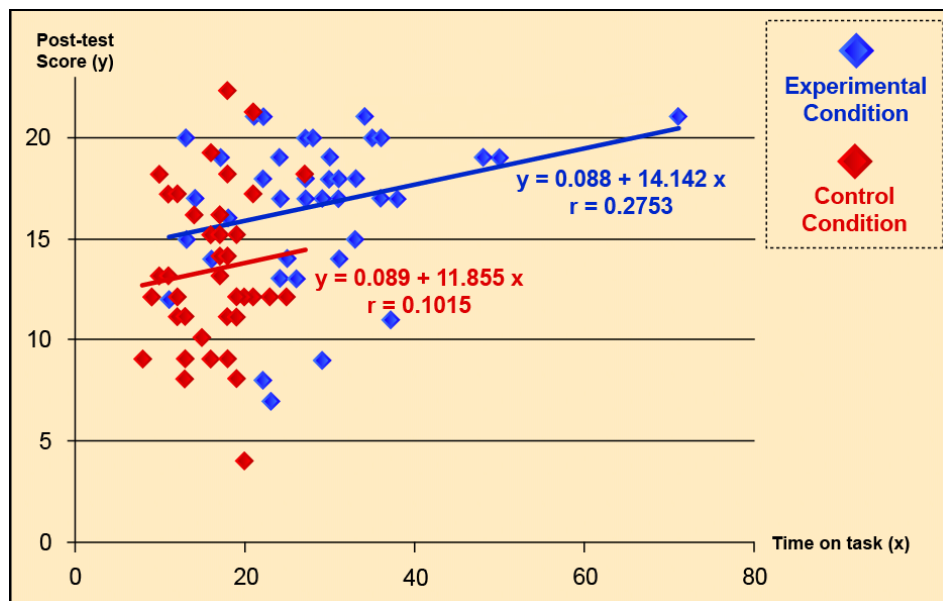
[1] Further, as the maximum amount of time that the participants can spend on their learning mediums was not defined by the researcher, the measure of time can also be used to indicate the level of engagement with the learning mediums. As mentioned earlier in the methodology and procedures chapter, the measure of time-on-task was conducted stealthy and the participants were not informed of this process (in order to prevent learning disruption).

Table 5.1: The descriptive statistic of time spent on the task for both study groups.

Central tendency / Dispersion	Time-on-task (Experimental Group)	Time-on-task (Control Group)
Mean	28.292	16.487
Median	27	17
Mode	22, 24, 27, 31, 36	17,18
Range	39	19
Standard Deviation	11.091	4.301
Variance	123.012	18.506

As mentioned in the methodology chapter, participants were told that they were expected to spend at least 15 minutes on their respective learning mediums. However, as indicated in the figure above, 13 participants (15.85%) spent less than 15 minutes on their learning mediums (3 participants from the experimental group and 13 from the control group).

There appears to be a weak correlation between the time participants spent on the task and the higher post-test score outcomes. However, the result did not appear to be statistically significant. Based on the findings, this study does not reject H_N.

5.2.2.1 Case study examples for the time-on-task

As suggested by the regression analysis, the correlation between time spent on the task (time-on-task) and the post-test score outcomes for both the experimental and the control group was not appeared to be statistically significant ($r < 0.5$ / $p > 0.050$). In other word, there appeared to be a weak link between the longer amount of time that participants spent on the learning mediums (game / reading material) and the high post-test scores.

For example, #P47-EXP spent the longest time on THE GROWTH at 71 minutes and obtained the post-test score of 21/23 – 15 scores in improvement.

On the other hand, #P1-EXP spent only 21 minutes on THE GROWTH and also obtained the post-test score of 21/23 (11 scores in improvement). Further, #P13-EXP spent only 22 minutes on THE GROWTH and also obtained the post-test score of 21/23 (15 scores in improvement). Additionally, #P77-EXP spent about 34 minutes on THE GROWTH and also obtained the post-test score of 21/23 (13 scores in improvement).

(Please see Appendix 06 for similar comparison on age groups and gender groups).

5.2.4 The difference in knowledge outcome between the male and the female participants (based on a set of multiple-choice questions)

H_N: There is no difference in knowledge outcome between the male and the female participants on average

H_1: The two groups have different learning outcome on average

5.2.4.1 Findings and the implications of gender analysis

As mentioned in the methodology and procedures chapter, 70 male and 12 female participants participated in this study. To this, participants can be categorized into 4 groups for the purpose of analysis by genders (2 genders $\times$ 2 study groups). The result from repeated measures ANOVA has shown statistically significant difference in knowledge attainment between gender groups; $F(1,78) = 6.873$, $p = 0.011$. Based on the findings, this study rejects H_N in favor of H_1.

In the post-test, the results show that both the males and the females from the experimental group outperformed their counterparts from the control group. This result is in agreement with the aforementioned 'overall knowledge outcomes between the two study groups' which shows that the experimental group has outperformed the control group in the post-test.

However, it must be emphasized that the size of female participants in this study accounted for only 17.14% of the size of male participants. Further, the low number of female participation in this study limits a meaningful generalization of result.

As evidenced by the interview and the gameplay observation, it should be noted that the relatively lower post-test scores of the female participants from the experimental group might be attributed to their disengagement with THE GROWTH. The gameplay observation shows that the female participants did not focus on the main game task (i.e. the quiz game function)[2] in the similar way to the majority of male participants.

Further, the analysis of the amount of time the participants have spent on the task (i.e. time-on-task) revealed that an average female participant spent less time on THE GROWTH when compared to an average male participant. This is shown in the table below.

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[2] For the experimental group, the answers to the pre- and post-test questions can be discovered through the interaction with the 'quiz game function'.

Figure 5.3: The pre- and post-test score comparison between male and female participants. The result from repeated measures ANOVA has shown a statistically significant difference in knowledge attainment between study groups ($F_{(1,78)} = 7.762$, $p = .007$) and also between gender groups ($F_{(1,78)} = 6.873$, $p = 0.011$).
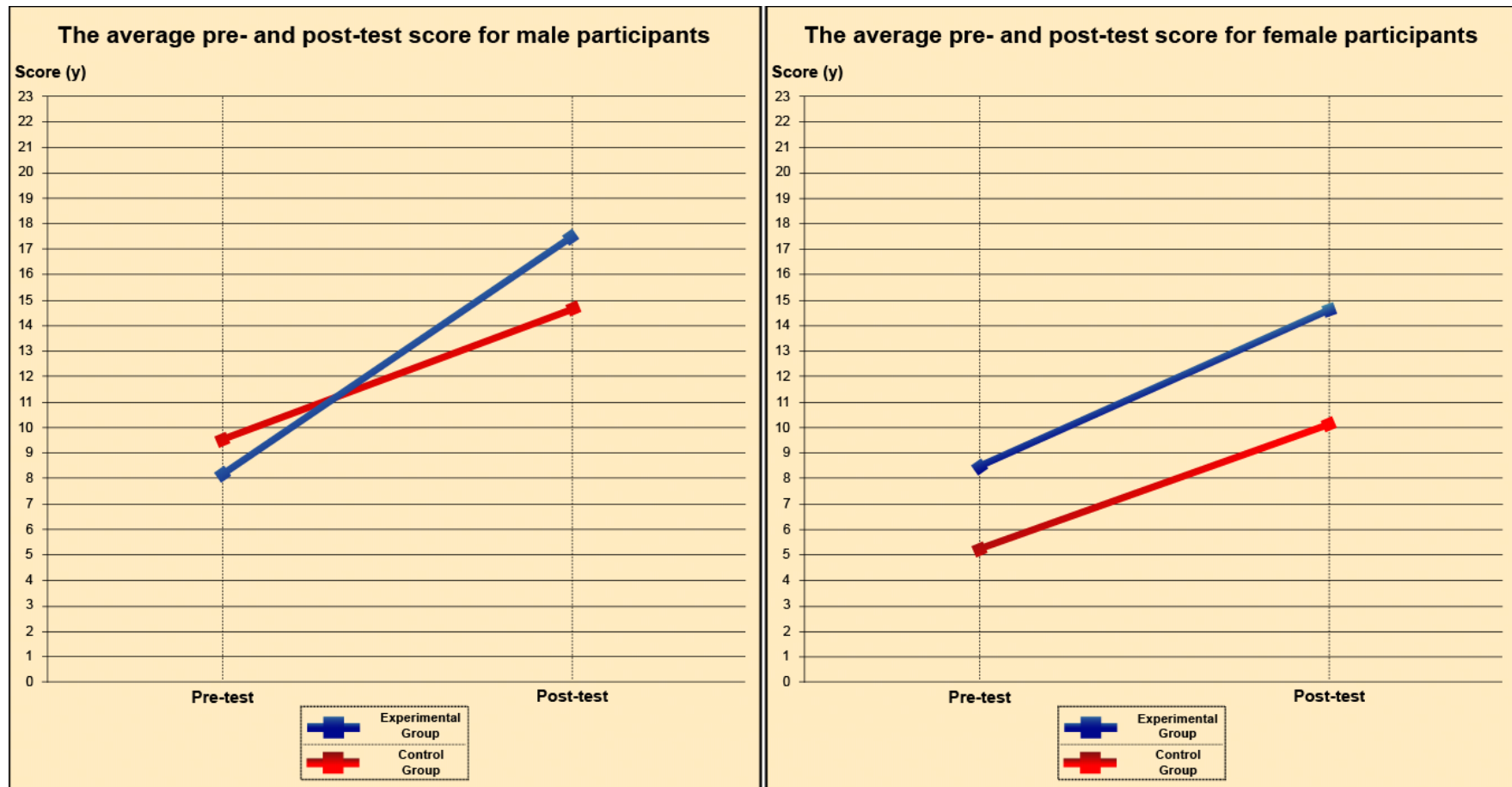
Table 5.2: Time spent on THE GROWTH (i.e. time-on-task) comparison between the male and the female participants for both study groups. The result is not statistically significant for both study groups as determined by the independent t-test, however (Experimental group; $t(39) = 1.5721$, $p = 0.124$ / Control group; $t(39) = 0.0074$, $p = 0.994$).

Central tendency / Dispersion	Experimental Group Male (N = 35)	Experimental Group Female (N = 6)	Control Group Male (N = 35)	Control Group Female (N = 6)
Mean	29.40	21.83	16.49	16.50
Median	29	20.50	17	16.50
Mode	22,24,31,36	14,16,18,23,27,33	17,18,19	16
Range	60	19	19	8
SD	11.33	7.25	4.55	2.66
VAR	124.70	52.57	20.73	7.1

Overall, this section of the analysis shows that all participants have gained an increase in knowledge outcomes after using the game / reading material – with the experimental group receiving greater improvement level when compared to the control group and the males receiving greater improvement level when compared to the females.

5.2.5 The difference in knowledge outcome between age groups (based on a set of multiple-choice questions)

H$_N$: There is no difference in knowledge outcome between age groups on average

H$_1$: Age groups have different learning outcome on average

Figure 5.4: The pre- and post-test score comparison between age groups. Note that: 1) there was only one participant from age group 18-20 in the experimental group and 2) age group 36-40 is missing in the control group because no participant from this age group was allocated into the control group.
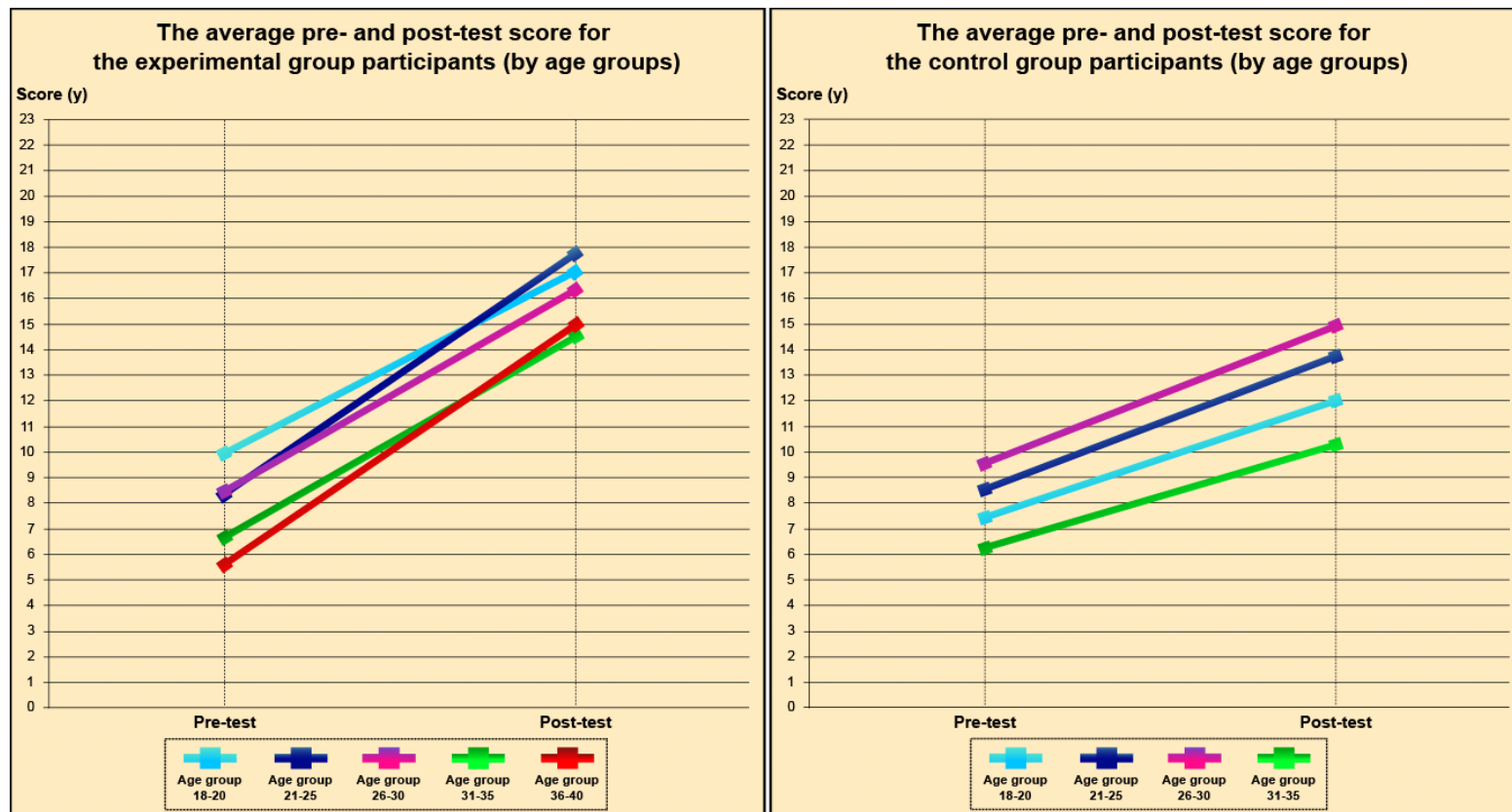
5.2.5.1 Findings and implications of age group analysis

The result from repeated measures ANOVA has shown a statistically significant difference in knowledge attainment between age groups ($F(4,73) = 2.541$, $p = .047$). Further, the result from Fisher's LSD (post-hoc) has shown a statistically significant difference in knowledge attainment between the following age groups: 21-25 and 31-35 ($p = 0.031$) and 26-30 and 31-35 ($p =.012$). Based on the findings, this study does not reject H_N. However, there are several points of interest and implications to this finding:

Contrary to the expectation that the younger age group assigned to the experimental group would learn better from the digital game-based learning environment, some younger age groups in this study did not obtain higher post-test score when compared to some older age groups. This inconclusive finding, however, may rest upon the number of reasons:

For example, gameplay observation indicates that each participant has his / her own gameplay style (also true across age groups). While some participants have focused on the quiz game function, others did not concentrated on the quiz function and simply browsed for the textual / graphical content in the game. Thus, limited interaction with the quiz function (as the central game mechanism where the core learning most occurred) may have contributed to the lower post-test scores of some participants.

The lower post-test scores for many older age groups, on the other hand, might be attributed to their gaming activities where the self-report on gaming activities indicates slightly lower engagement in game activities for older age groups participants when compared to participants from younger age groups.

Although a number of older age groups participants obtained relatively lower post-test scores when compared to younger age groups participants, interview sessions have revealed that the amount of topics recalled and discussed by many older age groups participants was on par with the younger age groups (this finding is consistent for both study groups). Additionally, many older age groups participants were able to reflect on the recalled topics more critically and in greater details when compared to some younger age groups participants.

Additionally, although the majority of participants did not disclose their personal information such as occupation, education, and income level, some participants have indirectly disclosed about the nature of their works / business, their association with the natural environment (e.g. agriculture, social responsibility, and tourism), and their responsibility over the utility expenditures. A number of these participants also able to reflect on the recalled topics during the interview in detail – indicating that age alone, may not be a reliable predictor for the learning outcome.

5.2.6 The difference in feedback on the learning mediums

H_N: There is no difference in feedback on the learning mediums between the experimental and the control group on average

H_1: The two groups have different feedback on the learning mediums on average

As mentioned in the methodology and procedures chapter, all 41participants from the experimental group were asked to complete the 'User Interaction Satisfaction survey' (QUIS). The aim of using the QUIS is to understand quantitatively about participants' reception after playing THE GROWTH.

On the other hand, all 41 participants from the control group were asked to complete a 'Reader Satisfaction survey'. This survey was modified from the QUIS. Questions related to the interactivity aspects were discounted from this survey as they were irrelevant to the control group participants.

Most questions used the 9-point Likert scale rating style. In survey questions targeting participants' experiences with the learning medium, rating 1-4 can be considered as 'poor', rating 5 can be considered as 'medium', rating 6 can be considered as 'medium-high', rating 7 can be considered as 'high', and rating 8-9 can be considered as 'very high'. This score interpretation is in line with digital game rating system used by game review websites (e.g. IGN and GAMESPOT). On the other hand, other survey questions determining the quality of 'font shapes' and 'system performance', rating 5 and below should be considered as 'negative feedback' as these usability factors should be maintained at the maximum level at all the time.

In this analysis, the comparison can be made where questions from both the QUIS and The Reader Satisfaction survey are compatible with each other (please also see the appendix 07 for a detailed analysis on the QUIS & The Reader Satisfaction survey).

5.2.6.1 The overall user VS the overall reader reaction

For the 'Terrible-Wonderful' section, the majority of participants from the experimental group (31/41; 75.61%) have rated their overall user reaction with THE GROWTH highly. On the other hand, the majority of participants from the control group (30/41; 73.17%) have rated their overall reading reaction moderately.

In 'Dull-Stimulating' section, the majority of participants from the experimental group (24/41; 58.54%) have rated this section highly (rating 7-8-9). On the other hand, only 6 participants from the control group (14.63%) have rated this section highly.

In 'Frustrating-Satisfying' section, the majority of participants from the experimental group (30/39; 76.92%) have rated this section highly (rating 7-8-9). On the other hand, only 5/41 participants from the control group (12.20%) have rated this section highly.

These results indicated that the majority of participants from the experimental group considered using THE GROWTH as a more pleasant learning medium when compared to the majority of participants from the control group who used the reading material.

Interestingly, in 'Difficult-Easy' section, only 11/40 participants from the experimental group (27.50%) have rated the game as 'easy' (rating 7-8-9) as opposed to 35/39 participants from the control group (89.74%). This outcome is predictable as the experimental participants have to interact with the game mechanism rather than being restricted only to the reading activity as in the control group. However, as indicated elsewhere in this chapter, the experimental group gained greater level of score improvements when compared to the control group – suggesting that the perceived level of difficulty in THE GROWTH did not appear to impede the learning activity of the experimental group participants.

5.2.6.2 Reading from the window screen VS reading from the reading material

The majority of participants from both groups did not report significant problems on reading from the computer screen / the reading material. This indicates that the font shape and the sharpness of characters were considered by the majority of participants in both study groups to be adequate.

Only few participants from both groups have reported moderate-significant reading problems from their learning mediums (rating 6 and lower). For the experimental group, observation from the recorded gameplay did not reveal signs of hardware / software problems and the cause(s) cannot be established.

5.2.6.3 Getting started

All 39/39 participants from the control group have reported that they have little-no problems in getting started with the reading material. Although several participants from the experimental group have reported certain level of difficulties in getting started with THE GROWTH, only few participants have reported major difficulties in getting started (rating 4 and below).

The majority of participants from the experimental group, however, appear to have little or no problems in getting started.

The results are predictable. As with 'Difficult-Easy' section analyzed above, participants from the experimental group have to interact with the game mechanism. Thus, it is unsurprising that the

participants have perceived their tasks as 'more difficult' when compared to the reports from many control group participants. Again, the reports of difficulties and obstacles encountered in THE GROWTH did not appear to impede participants' learning outcomes as evidenced from their post-test scores.

5.2.6.4 The summary from The User Interaction Satisfaction (QUIS) & The Reader Satisfaction analysis

As suggested by the analysis above, the majority of participants from the experimental group have perceived using THE GROWTH as more pleasant when compared to the majority of the control group participants who used the reading material. Based on the findings, this study rejects H_N in favor of H_1.

The majority of both study groups have rated the overall quality of their respective learning mediums highly (e.g. font shape, brightness, sharpness, screen / page size, and layout) – indicating that both study groups have perceived the overall quality of both learning mediums to be up to the standard.

5.2.7 The difference in responses towards the concept of pollution tax between the experimental and the control group

H_N: There is no difference in responses towards the concept of environmental tax between the two groups on average

H_1: The two groups have different responses towards the concept of environmental tax on average

As mentioned earlier, the interview was a part of the knowledge test for this study. The aim of the interview was to address the shortcoming of 'factual knowledge-only' test (used in the pre- and post-test). Additionally, interview can provide qualitative understandings about the participants' attitudes and reflections towards the environmental, social, and technological issues presented in the game / reading material.

Some of participants' statements can imply (if not predict) their behavioural intentions. These statements can be linked to the different types of environmental behavioural 'stances' as highlighted by Centre for Alternative Technology (2010) in detail.

To this end, participants have been asked to recall and describe about the environmental, social, and technological issues that they have learned from the game / reading material. 21 participants did not participate (or did not complete) this section due to personal reasons. Thus, only the results from 61/82 participants (29 from the experimental and 32 from the control group) will be presented in 'the total amount of topics recalled' (see the table below) while partial discussions from participants who did not participate in the interview fully will be presented separately[3].

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[3] Although a number of participants did not partake in the interview, some of them were still able to provide a 'short, summarized version' of the interview. While these statements were excluded from the main frequency counting table due to objectivity reasons, some statements are still insightful and worth of discussion.

On average, a participant from the experimental group has recalled about 9 items from the game while a participant from the control group has recalled about 7 items from the reading material.

Table 5.3: The descriptive statistics for the amount of items recalled by the experimental and the control group participants. The independent-samples t-test was performed and the result shows a statistically significant difference in the amount of topics recalled for the experimental group (M = 9.24; SD = 2.37) and the control group (M=7.34, SD=1.79); t (59) = 3.35496, p = .001.

Study group	Mean	Median	Mode	SD	VAR
Experimental (N=29)	9.24	9	9	2.37	5.62
Control (N=32)	7.34	7	6.7	1.79	3.20

A point was given to the participant for each topic recalled and described successfully. Because the aim of the interview was to understand about participants' attitudes and reflections on topics presented in the learning mediums, participants were not penalized for disagreeing with the intended messages of the topics as long as they could describe the meaning of topic(s) accurately. For example, a participant is given one point for recalled and described about the growing population issue accurately, even if s/he disagreed with the concept of family size planning.

5.2.7.1 Overview on the issues recalled & discussed by the participants

To minimize knowledge contamination[4], participants were asked to recall all issues at once. Subsequent issues recalled by the participants, although proved valuable, were discounted from the main frequency counting table.

The following table shows the top 5 most recalled topics from each of the three categories. (Please see appendix 08 for the full list of items recalled by the participants).

Table 5.4: The top 5 issues each of the three main categories (as recalled by the participants from both study groups).

Top 5 environmental issues	Top 5 social & welfare issues	Top 5 technological issues
Forest conservation	Crimes	Smart products
Pollution issues	Unplanned pregnancy	Solar technology
Public transportation	Growing population	Robotic & automation technology
Recycle	Food safety	Sustainable farming technologies
Garbage issues	War	Food processing & preservation technology

Notes:

- Garbage issues: include both land-based and marine garbage.
- Smart products: a number of items such as waterless toilets, energy efficient appliances, water efficient appliances, real-time metering system, and smart elevators were put under the umbrella of 'Smart products' (excluding 'heavy' robots).
- Robotic & automation technology: driverless vehicles, industrial robots, crime prevention robots (e.g. law enforcement robots and UAV) were included into this category.
- Sustainable farming technologies: backyard farming, organic farming, integrated aquaculture system, and waste-to-feed system were included into this category.

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[4] For example: accidental knowledge transfers that might have occurred during the interview or as the result of follow-up questionnaires or other inputs introduced by the researcher.

5.2.7.2 The ultimate question: "Would you agree with the concept of pollution tax?"[5]

After the main interview section, the ultimate question of the study was asked on 76/82 participants (37 from the experimental group and 39 from the control group) with the question: "Would you agree with the concept of pollution tax?"

The ultimate question aimed to detect participants' commitments towards pro-environmental actions / behaviours (using price manipulation). Explanation of the pollution tax concept was provided to all 76 participants as the following: "the price increase for all non-environmental friendly products such as factory-farmed and processed foods, electrical energy, tap water, vehicles, and electronic appliances".

As the result, the majority of participants (68/76; 89.47%) have expressed their disagreements with the concept of pollution tax. Within this, 31/37 (83.78%) were participants from the experimental group and 37/39 (94.87%) were participants from the control group. Based on the findings, this study does not reject H_N.

Thus, participants' statements on the ultimate question indicate that:

- The exposure to THE GROWTH game and the reading material did not appear to encourage the majority of participants to support environmental conservation through the rational of price manipulation.
- The responses from both study groups did not appear to be remarkably differed from each other.

To support their view points, some participants have made arguments for not supporting the pollution tax policy. These arguments include: financial difficulties, the dilemma of choices between the personal well-being and the environmental conservation, the possibility of social disturbances, possibility of corruption (e.g. transparency), and the expectancy that the new technologies would solve environmental problems (i.e. tech-fix).

On the other hand, only 6/37 participants from the experimental group and 2/39 participants from the control group have expressed their supports (or partial supports) towards the concept of pollution tax.

(Please see the appendix 09 for additional participants' statements on the pollution tax policy).

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[5] The ultimate question was also asked on participants who did not partake / did not complete the interview fully due to personal reasons.

5.2.7.3 Top 5 environmental topics

5.2.7.3.1 Forest Conservation

Forest conservation was the most recalled environmental topic by all participants. Overall, forest conservation was also the second most recalled topics after crimes.

The value of forest conservation

Participants from both the experimental and the control group have recognized the importance of forest conservation during the interview. For example, #P27-EXP has recognized the long-term benefits from forest products and also highlighted negative impacts from the forest encroachment. #P2-CTRL has recognized the importance of forests as the flood barrier and homes to wildlife. #P17-CTRL while discussed about environmental problems in general has also criticized luxurious social values and media for their roles in environmental degradation (promoting unsustainable lifestyles).

#P19-EXP, in similar to #P17-CTRL, has also criticized luxurious social values as one of the causes for the decline of natural habitats and resources. Further, the rich and the powerful were criticized by the participant for the perceived corruption.

Additionally, #P19-EXP had expressed his concern that the income from illegal activities gained from the forest encroachment could be used by criminals to create even more social problems. This concept of environmental-crime relationship was not addressed in the game / reading material – suggesting that the participant was able to reactively linking the current learning context to another. It was also hinted from #P19-EXP's statement that religious beliefs might play a role in his supportive attitudes towards the concept of environmental conservation (believed that wrongdoers would be punished in the afterlife).

- #P27-EXP – *"I think the nature works in similar way to 'the duck with golden eggs' story. You would be able to collect a golden egg from the duck continuously every day, but if you get greedy and rush the duck, the animal will die and you will get nothing at all".*
- #P2-CTRL – *"I think the forest is very important considering [the reading material] said that forest areas are diminishing in Thailand. All of us have been told that forest can reduce severity of flood. There are beautiful animals in the forest so it would be sad if we cut the trees and destroy their homes".*

(Please see the appendix 09 for additional participants' statements on the forest conservation).

Specific follow-up questions

All participants who recalled about the forest conservation were asked with two specific follow-up questions: "Who do you think is responsible for the forest protection?" and "Would you consider donating to support environmental conservation projects?"

Who do you think is responsible for the forest protection?

For the question: "Who do you think should be responsible for the forest protection?" It appears that the majority of participants (29/43; 67.44%) have put their expectations on the government (and the law enforcement). Within this, 17/23 (73.91%) were participants from the experimental group and 12/20 (60%) were participants from the control group.

On the other hand, 14/43; 32.56% think the public should / should also be responsible for the forest protection. Within this, 6/23 (26.09%) were participants from the experimental group and 8/20 (40%) were participants from the control group.

Some participants have suggested solutions and discussed problems around the forest protection. For example: #P3-EXP and #P21-CTRL have suggested that harsh penalties should be used to punish the offenders. #P40-EXP, apart from suggesting punishment, has expressed his concerns about the environmental degradation and the livelihood of the future generation. #P51-EXP has recognized the relationship between supply-demand from the illegal forest products. #P16-CTRL has emphasized the environmental impacts from heavy industries and suggested that public reports of environmental offenders could be used to help combat the problem[6].

Additionally, #P22-EXP has highlighted the idea of public supports on forest protection. Interestingly, he has also referred to the concept of 'Eco-celebrity' from the game when discussed under the topic of forest conservation (using the famous figures to encourage environmental conservation). The participant also referred to the real-life environmental information he has previously acquired from other media avenues.

- #P40-EXP – *"I think the government needs to solve this problem quickly. We need to punish environmental polluter. This is not about being hippies. This is about protecting the world for our children and many generations to come …"*
- #P16-CTRL – *"… the law must be enforced especially on heavy industries. People should help by notice the government of suspicious behaviours too".*

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[6] Although the direct reference was not made by this participant, the 'Environmental informant' is the concept in the game / reading material about reporting environmental crimes to the authority anonymously for the rewards.

(Please see the appendix 09 for additional information regarding of participants' statements on the responsibility of forest conservation).

Would you consider donating to support environmental conservation projects?

For the question: "Would you consider donating to environmental conservation projects?" Only 6/43 participants (13.95%) have expressed their supports towards the concept of environmental donation. Within this, 2/23 (8.70%) were participants from the experimental group and other 4/20 (20%) were participants from the control group.

In line with the result from the reception towards the pollution tax discussed earlier, this result indicates that exposures to THE GROWTH and the reading material did not appear to increase most participants' attitudes towards pro-environmental conservation through the rationale of financial donation.

In support for donation, the desire to help the natural environment has been cited by #P7-CTRL. #P10-EXP has expressed his support towards the donation, but emphasized that the government should be able to help accomplish the endeavor as well. #P40-EXP has expressed his support toward donation while recognize the appealing value of the natural environment. The participant also mentioned different methods for natural conservation.

In disagreement with donation for environmental projects, participants have cited reasons such as: the possibility of corruption and inefficiencies in the justice system on environmental crimes committed by the influential individuals (#P2-CTRL and #P79-EXP). Other participants also discussed alternative avenues to contribute to the natural conservation (#P3-EXP), the perceived poor efficiency of forest protection (#P51-EXP), and the previous unpleasant encounter with environmental organization's representatives as their reasons for not donating to the environmental conservation projects (#P57-CTRL and #P69-CTRL).

Some participants' accounts have suggested that they might donate under certain circumstances. #P79-EXP, for example, had initially expressed that he did not wish to donate, but changed his statement later and expressed that he might donate for a specific cause / reason. Some participants have suggested physical contribution as an alternative to donation (#P39-EXP and #P3-EXP).

- #P10-EXP – *"... I support wildlife and forest protection projects ... although my contribution is small. I think people with financial capacity should donate to protect the environment, but the government should be able to show some good works to the public too".*
- #P57-CTRL – *"... Sometime they want you to donate like [£2-5] every month and the money will be taken from the account automatically. I think it's so weird. It's my money and I should*

be able to do it without any commitments. Besides, I don't feel safe linking my bank account with someone else's".

(Please see the appendix 09 for additional participants' statements regarding of their agreements & disagreements on the concept of donation supports for environmental conservation projects).

5.2.7.3.2 Pollution issues

Pollution was the 2nd most recalled environmental issues after the forest conservation. A number of pollution issues have been recalled by the participants. Pollution topics recalled by participants include toxic contamination, air pollution, water pollution, and soil pollution. Participants have also recognized pollutions' negative effects on health and welfare.

Solutions for the pollution problems have been suggested by participants. Examples include: using law enforcement to apprehend environmental violators[7], shifting from private to public transportation to reduce air pollution, using advanced technology (i.e. tech-fix), and using 'name and shame' approach (e.g. exposing the violators on the online communities).

It appears that some participants are still focusing on the pollution from the point sources (e.g. factories) while ignoring the pollution from the residential sectors (e.g. #P4-CTRL and #P16-CTRL).

- #P76-EXP – *"When I read about water contamination, I think about garbage and pollutants being released into the river. … My group was in the meeting at the client's factory. The factory was discharging wastewater into the river while we were touring the other side of their factory. I think our guide was embarrassed by the event that he had to divert the tour to other section of the factory … "*
- #P4-CTRL – *"Water pollution can cause great pain. I was hospitalized once and the doctor said that it was caused by drinking polluted water …"*

(Please see the appendix 09 for additional participants' statements on the pollution issues).

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[7] Using law enforcement to combat pollution problems (environmental violators) appears to be the method of choice as cited by many participants.

Pollution issues as the side topic

In other cases, pollution problems have been described by participants while discussing other topics from the game / reading material.

- #P20-CTRL – *"... Some street food vendors would grill food in the open air, releasing a lot of smoke into the air. There are a lot of street food vendors in my area and the locals cannot leave the windows opened all day because of the smoke and oil fumes ... "*

(Please see the appendix 09 for additional participants' statements on the pollution issues as a side topic).

5.2.7.3.3 Public transportation

Public transportation was the 3rd most recalled environmental issue by the participants. The concept of public transportation was included into the game / reading material to highlight the benefits of cost-saving, pollution reduction and resources conservation that could be gained by switching from private to public transportation.

A specific follow-up question for the public transportation topic was: "If provided with the free fuel vouchers, would you choose to drive or choose to use the public transportation?" Participants have been told that the vouchers could not be transferred for other purposes. This question aimed to understand participants' level of commitments towards pro-environmental actions.

6/11 participants from the experimental group (54.55%) have expressed that they would drive (if provided with the free fuel), citing convenience, speed, and safety as the reasons. 3/11 (27.27%) participants, on the other hand, expressed that they would drive sometimes and use the public transport on other occasions.

Other 2/11 participants from the experimental group (18.18%) have suggested that they would use public transportation system. It should be noted that both participants have expressed that they live in close proximity to the transport hub(s). Thus, the convenience and accessibility offered could have been the important factor for their supportive attitudes of the public transportation.

On the other hand, 3/8 participants from the control group (37.50%) have highlighted that they would drive if provided with the free fuel. Similar to participants from the experimental group, convenience have been cited as the main reason. 5/8 participants (62.50%) have expressed that they would drive sometimes and use the public transport on other occasions – citing speed and convenience as the reasons.

The results from this specific follow-up question indicated that the majority of participants in this study would still choose personal benefits (e.g. convenience) over the environmental benefits – highlighting the gap between environmental awareness and pro-environmental actions.

At the same time, a number of participants have discussed the benefit of using public transportation in term of convenience and cost-saving rather than the environmental and health benefits of decreased air pollution – suggesting that both the personal and financial gains might be the topic of higher priority for many participants.

- #P1-EXP – *"... I've travelled to some countries and their public transportation system is something we could learn from. <[]> Take Germany for example, they have an efficient public transportation system so many people are using them and there's not much traffic congestion problems over there ... "*
- #P55-CTRL – *"If we have efficient public transportation system at reasonable price then I believe that people including myself will want to use them.*

(Please see the appendix 09 for additional participants' statements on the public transportation issue).

5.2.7.3.4 Recycling

Recycling was the 4th most recalled environmental issues. Participants who have recalled and discussed about recycling were asked with two specific follow-up questions: "How often do you practice recycling?" and "Would you practice recycle often in the future?"

Only 6/16 participants (3 from the experimental and 3 from the control group) have reported to practice recycling. The frequency of recycling practice varied from one participant to another and no participant has reported 100% household recycling rate.

Interestingly, the term "waste dealer" (travelling merchants who barter for recyclable wastes by offering cash or other objects of values in return) has emerged from the discussion with several participants. For some participants, waste dealers are the key factor for them to practice recycling – either for the financial benefit (e.g. #P7-CTRL) or for social cooperation (e.g. #P72-CTRL).

The majority of participants who have recalled about recycling (3 from the experimental and 7 from the control group) have revealed that they cannot practice recycling (at least on the daily basis) due to convenience and accessibility issues among others. Due to these issues, participants' viewpoints have not changed after asked with the question: "Would you practice recycle often in the future?" This highlights the gap between environmental awareness and pro-environmental

actions. It also highlighted the real-world obstacles that could potentially prevent the populace from practicing recycle (e.g. lack of access to recycle waste collectors).

- #P4-CTRL – " … [I don't practice recycling because] there's no recycling station in my apartment. <[]> If I have time I'll do it. But it would be good for the apartment to put the recycle bin on each floor as I don't want to carry recycles down to the ground floor every time".
- #P60-EXP – "… It's social responsibility for me. <[]> Like, you can do recycle to help keep the world clean and prevent people from getting sick at the same time. I think it's a sinful act if you don't do it simply because you're too lazy to do it …

(Please see the appendix 09 for additional participants' statements on the recycling issue).

5.2.7.3.5 Garbage issues

Garbage was the 5th most recalled environmental issue. 14 participants who recalled about the garbage issue have been asked with a specific follow-up question: "What can you do to reduce garbage problem?" In answering this specific follow-up question, participants have suggested reuse (#P30-EXP and #P22-EXP), sustainable lifestyles (#P30-EXP), using law enforcement (#P38-CTRL, #P60-EXP, and #P71-EXP), and using advanced technologies (#P57-CTRL and #P64-CTRL) as the solution to manage garbage issues.

- #P60-EXP – "… I've heard about some wild animals have died from ingesting garbage too …"
- #P38-CTRL – "Garbage is a serious pollution problem … along with industrial wastes being released into the ocean, overfishing and demands for seafood …"

(Please see the appendix 09 for additional participants' statements on the garbage issues).

5.2.7.4 Top 5 social topics

5.2.7.4.1 Crimes

Crime was the 1st most recalled social & welfare issues (also the most recalled topics in general). This is a relatively surprising finding considered that the core concept of THE GROWTH is about environmental conservation. However, this presents an opportunity for integrating crime as an example of social disturbances originated from the environmental degradation, resources conflicts, and failing social well-being.

Crimes such as narcotics, corruption, slavery, violent crimes, and sexual assaults have been recalled and discussed by the participants. Additionally, a number of participants have also referred to crime cases either from media reports or their personal encounters with crimes.

The majority of participants have suggested severe punishments as the solution for crimes when asked with the question: "What do you think we should do to reduce crime problems in our country?"

- #P72-CTRL – *"... I think such vicious crimes should be treated with the same punishment as adults. I can accept that 10-year-old boys might hurt other people because they are too young. However, the chance for them to actually kill someone would be slim because they are small in size ..."*
- #P81-EXP – *"… I think if we can deploy warships or build networks of defensive platform like in the game then we would be able to deploy helicopters or robots in response to distress calls from the cargo ships ..."*

(Please see the appendix 09 for additional participants' statements on the crime issues).

5.2.7.4.2 Unplanned pregnancy

Unplanned pregnancy was the 2nd most recalled social & welfare issue by the participants. Instead of discussing unsustainable population growth from environmental-only perspective, unplanned pregnancy issue was included into the game / reading material to highlight both the environmental and social issues stemmed from the unsustainable family planning.

Participants who have recalled about the unplanned pregnancy have been asked with 2 specific follow-up questions: "What do you think we should do to reduce unplanned pregnancy rate?" and "What, in your opinion, should be the maximum size of children per family?"

The majority of participants have suggested contraceptive devices as the solution for unplanned pregnancy issue (N=20). A number of participants have also suggested sexual education as the

solution (N=13). Only few participants have suggested abortion as the possible solution for unplanned pregnancy issue (N=3).

For the maximum size of children per family, 15/24 participants have suggested 2 children per family, 7/24 participants have suggested a child per family, and 2/24 participants have suggested 3 children per family.

When combining the results with participants who have recalled about 'the growing population' issue, 19/38 participants have suggested 2 children as the maximum children size per family, 17/38 participants have suggested a child per family, and 2/38 participants have suggested 3 children as the maximum children size per family. This suggests that the overwhelming majority of participants who recalled on these issues are agreeing with small-size families. The responses were not remarkably differed between the two study groups.

- #P36-CTRL – *"I think parental responsibility is very important. Children welfare will suffer if they were raised by irresponsible parents. Also, these children might be turned into criminals one day so they will be dangerous to the public ..."*
- #P10-EXP – *"I think people should think carefully. Getting pregnant is a serious business because the children will need supports from their parents for at least 15-20 years ..."*

(Please see the appendix 09 for additional participants' statements on the unplanned pregnancy issue).

5.2.7.4.3 Growing population

Despite being the central theme of the game, the growing population issue was the 3rd most recalled social & welfare topics (11th most recalled topics overall). Only 14 participants (11 from the experimental group and 3 from the control group) have recalled about growing population issue after using the game / reading material.

Participants who have recalled about growing population issue have been asked with 2 specific follow-up questions: "What do you think we should do to reduce growing population issue?" and "What, in your opinion, should be the maximum size of children per family?"

4/14 participants have suggested 2 children per family while 10/14 participants have suggested a child per family.

When combining the results with participants who have recalled about 'the unplanned pregnancy' issue, 19/38 participants have suggested 2 children as the maximum children size per family, 17/38 participants have suggested a child per family, and 2/38 participants have suggested 3 children as the maximum children size per family. This suggests that the overwhelming majority

of participants who recalled on these issues are agreeing with small-size families. The responses were not remarkably differed between the two study groups.

For many participants, the growing population issue was referred to in the social context (e.g. children and family welfare, poverty, drugs, and crimes) rather than the environmental ones. This suggests that the aspect of social implications can be used to draw the participants into the problem better than relying on the environmental-only model.

Interestingly, a participant has expressed his disagreement with the growing population issue (e.g. #P47-EXP). The participant's statement can be linked to both the 'fatalism' and 'it won't affect me' stances as highlighted by Centre for Alternative Technology (2010: 153).

While the majority of participants have suggested family planning programs, sexual education, and contraceptive devices as the solution for unplanned pregnancy issue, several participants have included wars and disease outbreaks as the possible solutions for growing population issue. These could be linked to the 'fatalism' stance as highlighted by Centre for Alternative Technology (2010: 153).

- #P11-EXP – *"It's depressing to hear about people dying from starvation. I've seen some photos about malnutrition problems in some countries. The children have to eat rotten foods. I've heard that in some countries the adults have to kill and eat the children because they have nothing to eat ... "*
- #P67-CTRL – *"I know some people whom I'd encourage them to have many children because they are very good people so they would be able to teach their children the right thing and it's likely that their children will set good examples for people of the next generation ..."*

(Please see the appendix 09 for additional participants' statements on the growing population issues).

Growing population as a side topic

Although the topic was not recalled directly by the participants, growing population issues have been indirectly referred to by the participants while discussing on other topics.

- #P12-CTRL – *"... Maybe it is because there are too many people on the planet and that's why manufacturers need to come up with things like pesticides and genetically-modified foods to feed millions of people. <[]> Well, I think it helps the situation temporality, but also cause health impacts ... "*

(Please see the appendix 09 for additional participants' statements on growing population issues as a side topic).

5.2.7.4.4 Food safety

Food safety was the 4th most recalled social & welfare topics by the participants. Food safety issue was included into the game / reading material to highlight the health safety in large-scale food production and pollution contamination in food.

A specific follow-up question for participants who have recalled about food safety issue was: "What do you think we can do to improve food safety?"

6/12 participants have suggested using the law to enforce food safety. Other opinions being: using technology, buying products from credible sources, growing vegetables for personal consumption, and reporting irresponsible food producers using social media (i.e. name and shame).

- #P20-CTRL – *"Some food vendors use dangerous chemicals to make food look appealing to the customers ...<[]> We need to regulate food vendors by issuing them with licenses. If people report them for hygiene problems then the government can revoke their licenses".*
- #P40-EXP – *"... The internet can be used to share information about food safety. Sometime people would post on the internet and the news spread quickly. <[]> There was a case where someone ... presumably a restaurant staff posted a video clip about the unhygienic kitchen which led to the closure of the restaurant ..."*

(Please see the appendix 09 for additional participants' statements on food safety issue).

5.2.7.4.5 War

War was the 5th most recalled social & health issue by the participants. The concept of war was included into the game / reading material to highlight environmental issues generated by the military sector and the possibility of armed conflicts over resources disputes.

- #P49-CTRL – *"I think war, along with environmental problems will bring about the end of humanity. In ancient times, people would just use swords and spears for fighting, but today's wars involve the use of hazardous weapons such as bombs and rockets so we are causing damage to the natural environment as we fight among ourselves".*

- #P56-EXP – *"... A lot of people especially the innocent will be killed and a lot of resources will be wasted. If nations can stop waging wars then maybe the military can help police force on internal security to reduce crime level ..."*

(Please see the appendix 09 for additional participants' statements on war).

5.2.7.5 Top 5 technological topics

5.2.7.5.1 Smart products

Smart products were the 1st most recalled technological topics by the participants. A number of smart products have been included into the game / reading material to highlight modern innovations that could be used to improve the quality of life and the environment at the same time.

Although some participants have recognized environmental benefits provided by the smart and innovative products, a number of participants appeared to recognize smart products in terms of convenience and financial benefits alone.

- #P13-EXP – *"... I think it will be useful because we would be able to monitor our [energy / water] usage all the time ..."*

- #P37-CTRL – *"... Also, some people use tube squeezers to extract the remaining toothpaste left in the tube. <[]> I don't have [a tube squeezer] at home, but my dad would cut the toothpaste container in half so he can use all remaining toothpaste left in the tube ..."*

(Please see the appendix 09 for additional participants' statements on the smart products).

5.2.7.5.2 Solar technology

Solar technology was the 2nd most recalled technological issue by the participants. Solar, along with other renewable energy technologies (e.g. wind and wave) were included into THE GROWTH / the reading material to highlight the benefits of using sustainable energy technology.

A specific follow-up question: "Would you like to invest in solar technology?" was asked on all participants who have recalled on solar technology.

The majority of participants (27/32; 84.38%) have expressed their interests in purchasing solar technology. 15/17 were participants from the experimental group and 12/15 were participants from the control group.

However, a number of participants who have expressed their interests in purchasing solar technology also highlighted obstacles that prevent them from doing so. Some of the obstacles highlighted by the participants include: high capital cost, slow return of investment (ROI) rate, insufficient technical knowledge, confidence issues (durability, reliability, and services), ease-of-use, and portability.

Some participants who have indirectly disclosed their association with business and management backgrounds appeared to discuss the financial incentives from installing solar technologies in great details when compared to other participants.

- #P2-CTRL – *"I think solar panels have been around for many years but the problem is that it's too expensive and people cannot afford them. However, since we now have the technology to make solar panels cheaper then I think people would want to have one on their roof ..."*
- #P76-EXP – *"... I would like the engineers to one day, design solar panels that could be expanded or folded like an umbrella. This way, people can decide whether they want the sunlight to reach the ground or not ..."*

(Please see the appendix 09 for additional participants' statements on the solar technology).

5.2.7.5.3 Robotic technology

Robotic technology was the 3rd most recalled technological issue by the participants. In this category, robotic technology is mostly referred to 'mobile robots' as opposed to 'stationary manufacturing robots'. A number of robotic applications have been included into the game / reading material. Examples include: driverless vehicles (promote quality of life, optimize energy consumption, and reduce accidents), humanoid / animal-liked robots, and crime prevention robots.

The technology was included into the game / reading material to highlight the possibility of using robots in environmental, social, health and welfare, and economic sector.

- #P1-EXP – *"... It will be good in the long run because you don't have to pay for the workers. You don't have to pay for insurance, medical bill, and you don't have to worry about people quitting their jobs. Productivity can also be increased because they can be put to work 24 hours a day without violating the labor law".*

- #P68-CTRL – *"... However, we must be careful here because machines require energy ... unless those machines can be powered by the clean energy. Also, if used to harvest products from natural habitats, machines will speed up the harvest process which can lead to animal extinction as well".*

(Please see the appendix 09 for additional participants' statements on the robotic technology).

5.2.7.5.4 Sustainable farming technology

Sustainable farming technology was the 4th most recalled technological issue by the participants. As mentioned earlier, several items from the game / reading material such as backyard farming, organic farming, integrated aquaculture system, and waste-to-feed system have been put under the umbrella of sustainable farming technology.

Sustainable farming technology was included into the game / reading material to highlight advanced farming technology and technique that could be used to increase productivity while minimize impacts on the natural environment.

- #P13-EXP – *"I've read about tending gardens will make one more concerned about the environment ... not far from my place is an empty plot of land and it has been abandoned for many years now. Imagine if someone can actually plant some seeds to grow vegetables ..."*
- #P2-CTRL – *"I think [backyard farming] is a good idea because people can grow their own vegetables for free and without pesticides ... and we won't be making waste from packaging too".*

(Please see the appendix 09 for additional participants' statements on the sustainable farming technology).

5.2.7.5.5 Food processing & preservation technology

Food processing technology was the 5th most recalled technological issue by participants. The technology was included into the game / reading material to highlight advanced technology that could be used to enhance productivity and speed of food industry while reducing food waste and environmental pollution.

- #P47-EXP – *"... It's true [that freezer storage incurs additional electrical cost], but that electrical cost is still cheaper than the cost of food waste. Besides, electrical cost can be minimized by provided that one doesn't open the freezer's door often".*
- #P73-CTRL – *"Food preservation technology is very important. <[]> Like, the idea of using radio waves to kill insects because it sounds like an environmental-friendly technology ..."*

(Please see the appendix 09 for additional participants' statements on food processing & preservation technology).

5.2.7.6 The summary from the interview

The result shows that the responses towards the concept of pollution tax were not statistically differed between both study groups. Disappointingly, it appeared that the majority of participants in both study groups have declined to participate and / or respond unenthusiastically on the subject. Based on the findings, this study does not reject H_N.

The result shows that on average, a participant from the experimental group was able to recall slightly more topics from THE GROWTH when compared to a control group participant recalled from the reading material. The overwhelming majority of participants from both study groups were able to described and reflect on the topics that they have recalled successfully.

There are few cases where incomplete / wrong information have been recalled by the participants, however (please see the discussion chapter).

Almost all participants from both groups have discussed and shown their supportive attitudes towards the concept of environmental conservation. However, the majority of participants from both study groups have declined to agree on the concept of 'pollution tax'. In other word, it appears that the majority of participants from both study groups were unwilling to support the environmental conservation financially. Some of the participants' statements have highlighted the perceived social implications behind this policy (e.g. corruption, social disturbances, and mismanagement).

Similarly, the majority of participants from both study groups who recalled on environmental topics such as 'Recycling' and 'Public transportation' have declined (or partially declined) to

participate in those pro-environmental actions. Although the real-world implications such as safety, usability, and accessibility have been cited by the participants as the reasons, these findings highlighted that THE GROWTH and the reading material were not effective in persuading the participants towards pro-environmental behaviours. Further, these findings highlighted the gap between environmental knowledge and the pro-environmental action (Coyle 2005).

It appears that the majority of participants who discussed on the pollution issues are still recognizing industries as the main source for environmental pollution while the pollution from households did not receive the similar attention. This finding suggests that the next iteration of THE GROWTH should be focused on presenting the environmental pollution problems from the residential sectors.

In what can be linked to the 'fatalism stance' (Centre for Alternative Technology 2010: 153), few participants have expressed (or partially expressed) their resignation towards the concept of environmental conservation due to the perceived overwhelming environmental (e.g. it's too late) and social issues (e.g. corruption).

The government and law enforcement were cited by many participants from both study groups as the solution for environmental problems in the country. Interestingly, few participants have shown their sympathies towards the poor and unfortunate and suggested that the environmental laws should be relaxed for them. Further, the 'blaming effect' was detected in several participants' statements. Some participants blamed 'the rich' and 'the influential' whereas other blamed 'the poor and 'the unfortunate' as the causes for environmental degradation.

A number of environmental topics were recalled and the participants were able to link the environmental to the social and health issues during the discussion. Additionally, the economic benefits from the environmental conservation were recognized by the participants – indicating that both topics can be linked together to reach out to non-environmental conscious participants (as highlighted in the GEG chapter).

A number of social topics have been recalled and discussed by the participants from both study groups. As with issues from the environmental topic, the majority of participants who recalled on the social topics have suggested the law enforcement as the solution to social problems in the country.

A number of sustainable technologies have been recalled and discussed by the participants from both study groups. Interestingly, participants (especially male participants) have discussed the use of technology extensively. Moreover, the majority of participants who have recalled on sustainable technologies have shown their interest in procuring these technological items.

The motivations for the majority of participants who recalled on technological items, however, appeared to be stemmed from the perceived convenience and financial benefits from utilizing these technological items (similar to the aforementioned relationship between the economic advantages and environmental conservation). Moreover, it appears that participants who have reported themselves as business owners have discussed the utilization of technological items in greater details when compared to other participants (e.g. the capital cost, geographical / meteorological factors, return of investment (ROI), maintenance, and reliability issues). This finding suggests that technological items and innovations, if presented properly, can be used to persuade the participants towards the concept of environmental conservation.

5.3 Conclusion

This chapter has presented and analyzed the findings obtained from participants during the experimental sessions. The factual knowledge test, as a part of the learning outcomes investigated in this study suggests that a digital game can increase participants' knowledge related to environmental and social issues. Additionally, participants from the experimental group (game group) appeared to gain greater level of factual knowledge when compared to participants from the control group (the reading group). This result appears to be statistically significant. As observed from the recorded gameplay, the greater increase in knowledge outcome for the experimental group might be attributed to several factors such as the instant feedback, the in-game reward system (i.e. resources), and the effect of 'Frequency of Repetition'[8] offered in the game. Moreover, the experimental group participants were able to recall and discussed more environmental and social topics from the game when compared to participants from the control group recalled environmental and social topics from the reading material. Thus, these findings answered the study's first research question by indicating that a digital game can be used as an appropriate environmental learning medium, especially when compared to the traditional classroom-based reading activity.

For the motivational value of using a digital game in the environmental learning context, the surveys used in this study (QUIS / Reader Satisfaction survey) have suggested that participants from the experimental group (the game group) appeared to satisfy with the game (e.g. high feedback rating). A number of experimental group participants, especially the participants from younger age groups, also commented about the game positively during the interview. Moreover, participants from the experimental group appeared to spend a considerable amount of time on the game (especially when compared to the control group participants) – suggesting that the game can sustain their attentions and increase their motivations. Additionally, the recorded gameplay

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[8] Observed gameplay revealed that a number of participants from the experimental group were able to correct the wrong answers that they have made earlier (see Knowles, Holton and Swanson 1998: 74).

indicated a high level of interaction between the players and game activities. In other word, many participants assigned to use the game appeared to be engaged with game activities during their session. Thus, these findings once again answered the first research question by demonstrating that a digital game can be an engaging environmental learning medium for many learners.

The interview sessions indicated that the majority of participants are aware of the man-made environmental impacts and / or the consequences. Contrary to the expectation however, only 14 participants (11 from the experimental and 3 from the control group) have recalled and discussed about the growing population issue presented in the learning mediums (explanation will be discussed in the discussion chapter). Yet still, a number of unsustainable population size issues are being discussed and / or mentioned by the participants indirectly under other contexts. These contexts include: the unplanned pregnancy, education opportunities, financial welfare, social welfare, and health welfare. These findings answered the second research question by indicated that an environmental game designed based on The Guideline for Environmental Games (GEG) can help the learners recognizing a number of man-made environmental and social issues faced in the real-world.

The obstacles that prevent participants' from adopting sustainable lifestyles they have learned into the real-world (research question 3), on the other hand, can be wide-ranging. While some participants have cited 'efforts, time, and financial situation' to be the main obstacles, others have also cited the inaction from the business, the society, and the government as their reasons for not committing to the sustainable lifestyles (i.e. "Others are not taking initiative / not doing well enough"). These findings demonstrated that despite the environmental knowledge gained, a number of participants still refused to commit to sustainable lifestyles. The Guideline for Environmental Games (GEG) and THE GROWTH alone might not be an adequate mean to encourage pro-environmental actions from the players and other alternative avenues must be explored further.

The next chapter will discuss the implications and limitations to the interpretation of findings in this chapter.

6. Discussion & Limitations

6.1 Introduction

This chapter discusses the implications and limitations to the interpretation of findings from the previous chapter. Topics of discussion in this chapter include: the possible explanations for the higher knowledge acquisition in the experimental group, the implications to gender and age group analysis, the shortcomings of certain game designs and experimental designs, the inclusion of social and financial elements in the environmental learning context, and the participants' viewpoints and resolutions towards the environmental and social issues presented.

6.2 The higher post-test scores from the experimental group (game group) participants

As suggested in the findings chapter the experimental group appears to gain higher post-test score when compared to the control group. The result also appeared to be statistically significant.

A number of factors may have contributed to the greater level of knowledge outcomes for the experimental group participants. For example, the observation from the recorded gameplay indicated that the majority of the experimental group participants[1] devoted significant efforts on the 'quiz function' of THE GROWTH (in what appears to be the attempts to gain the in-game resources). To this end, the interaction with the quiz game function might have contributed to the higher post-test score as all the 23 questions administered previously in the pre-test can make random appearances from the pool of quiz questions.

Additionally, the experimental group participants' overall higher post-test scores might be attributed to the 'attributional feedback system' in THE GROWTH where the system informs the players about their performance in a real-time manner (see Keller 2010: 52, Prensky 2007: 128). The observation from the recorded gameplay also revealed that a number of participants have made mistakes (i.e. choosing the wrong answers) during the initial stage, but managed to correct much of their mistakes during subsequent encounters with the same quiz question(s) – partially confirming the effect of 'Frequency of Repetition' where multiple attempts on the mistakes can contribute to improvements, as discussed by Knowles, Holton and Swanson (1998: 74).

On the other hand, the participants from the control group were assigned to use a non-interactive learning medium. Although the reading material contains identical textual and graphical information to THE GROWTH, it might be assumed[2] that the lack of interactivity, the lack of task-based rewards (see Ryan, Mims and Koestner 1983), and the lack of feedback, among other factors, may have contributed to the lower average post-test scores for the control group.

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[1] Especially the male participants from the younger age groups
[2] In contrast to the experimental group, direct observation cannot be made in the control group because the practice can be very invasive.

6.3 Target players: female participants

Female participants appeared to demonstrate less interest in both learning mediums as indicated by their responses (and by gameplay observation for the experimental group). As mentioned in the findings chapter, a female participant has expressed her disapproval with the graphical representation in the game and linking it to 'game for men'. The issue of game representation and the gender has been noted in some studies (e.g. Greenberg et al. 2008, Carr 2005, Squire 2011: 171-172).

4 females (1 from the experimental and 3 from the control group) have obtained lower than 50% score in the post-test. Although not remarkably differed, some female participants also have a slightly lower amount of topics recalled during the interview when compared to the male participants. The future development should consider game elements that could be used to attract the female audiences.

However, it should be noted that this study has a relatively low male-female participation ratio (female participants = 12 or 14.63% of the participation size) – limiting the meaningful generalization of the result. Moreover, a higher proportion of female participants did not complete the interview section when compared to the male group (F = 33.33%; M = 24.29%). To this end, the future study including larger female proportions could provide a more conclusive result.

6.4 Target users: the older age group

As indicated by the post-test knowledge outcomes, some older age group participants appeared to gain lower post-test scores when compared to some younger age groups. For participants assigned to the experimental condition, this issue might be attributed to older age group participants' interaction with the game where some of them simply browsing and reading the content rather than focus on the actual game activity (for most of the answers to the knowledge test can be found in the quiz game function). However, it should be noted that the imbalance of participant size in some age groups can potentially limit the meaningful generalization of the result.

On the other hand, older age group participants' ability to recall game topics appeared to be on par with participants from younger age groups. This indicates that the knowledge was gained through the reading of game content where it was assessed in the interview process, but not in the main test of factual knowledge.

The time spent on game activities for older age group participants assigned to the experimental group was also on par with experimental participants from other age groups[3] (also see the appendix section on the time-on-task between age groups). Additionally, the observation from recorded gameplay and responses obtained from the Questionnaire for User Interaction Satisfaction survey (QUIS) indicates that older age group participants did not experience major difficulties in learning how to use the software. In other word, time spent on the game was unlikely attributed to the technical difficulties.

6.5 The greater topic recall rate from the experimental group (game group) participants

Apart from the higher average post-test score, the experimental group participants also appeared to recall more topics from the game when compared to the control group participants who recalled from the reading material. To this end, their higher amount of topics recalled might be attributed to the higher level of engagement with THE GROWTH. This possible explanation is partially supported by some studies showing that the aspect of uncertainty in the game can contribute to the higher level of motivation / engagement Howard-Jones and Demetriou (2008) and Koster (2005: 116) as well as promoting the learners' curiosity (e.g. Keller 2010: 47).

6.6 The lower content recall on the 'trivial section'[4] from the experimental group when compared to the control group

From the observation of the recorded gameplay, it was found that not many participants from the experimental group have visited the 'trivial section' in THE GROWTH (this section is not the main part of the gameplay, but is accessible by pressing a GUI icon). Some participants who have discovered and accessed this section, however, have also visited other trivial sections, spent their time reading the information within, as well as recalled some of the content from this section as well.

Given that an average experimental participant spent about 28 minutes on THE GROWTH (M = 28.29; SD = 11.09), it was found that many participants have yet to discovered the 'trivial section' of the game. If the participants were to spend longer time on the game, they might discover other game functions along with additional environmental and social contents.

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[3] Time spent on the game for the older age group (31-35): M=39.6; SD=17.82; VAR=317.8 versus time spent on the game for younger age groups (20-25 and 26-30): M=28.14; SD=11.42; VAR=130.5. If the outliner (a participant from age group 31-35 who spent 71 minutes on the game) is removed from the calculation, then time spent on the game for older age group would be: M=31.8; SD=3.6; VAR=12.9 which is not significantly different from the younger age groups.
[4] The trivial section is presented in both THE GROWTH and the reading material. This is where the concepts from the game are linked to the real-world information. For example: the concept of the 'Affordable & Biodegradable Solar Panels' presented in the learning mediums were linked to the real-world information on the recent developments in solar technologies. Thus, the trivial section facilitates as the 'information bridge' between the fantasy world of the game and the real-world.

Further, the recorded gameplay showed that a number of participants from the experimental group were focused on the main game task (answering questions from the quiz section) that a number of other game functions[5] were barely visited.

On the other hand, the contents from the trivial section were clearly revealed to the control group participants in the reading material. This might explained their slightly higher rate of content recall from this section. Also, the lower rate of content recall from the trivial section for the experimental group participants might be attributed to the non-interactive tutorial design of THE GROWTH. This means that not many participants have revisited the tutorial function so they might not be aware of the 'trivial section'.

6.7 Low recall rate on the growing population issue

Participants from both the experimental and the control group did not recall on the growing population issue as much as they have recalled on other topics from the learning mediums. This is a surprise finding considered that the growing population issue was the central issue presented in the learning mediums.

A possible explanation could be attributed to the presentation issue: In THE GROWTH, the introduction storyline which tells the participants about the unsustainable growth of the human population was not shown to the participants at the start of the game (even though the participants can access a game function to view this information). This is in contrast to many games, especially in the commercial games, where the introduction storylines are usually shown at the start of the game and cannot be skipped. The recorded gameplay shows that only few experimental participants have accessed the introduction storyline.

6.8 The variety of content

A number of environmental, social, and technological issues have been presented in the learning mediums to highlight various issues at both local and global level.

As appeared in the knowledge outcomes, the variety of content presented did not appear to obstruct the participants' learning process (e.g. cognitive overload). On the other hand, an average participant was able to recall a number of environmental, social, and technological topics from the game / reading material (7-9 topics) within a relatively short amount of time as discussed previously in the findings chapter.

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[5] Other game functions include the upgrade, the investment, and the special actions functions

Further, several participants have responded positively on the variety of content presented in the game / reading material during the interview. This finding suggests that multiple issues could be included into the game to expose players to various socio-environmental issues.

Indeed, the game mechanisms in many modern games are becoming increasingly complex thanks to the advancement in computer technology. Computer games can also handle multiple variables automatically and simultaneously, limiting the players' inputs at micro-level and preventing mental fatigue and cognitive overload – allowing the players to focus on other important game tasks.

Additionally, a number of players especially the so-called 'hard-core gamers' are demanding for games with high level of complexity (e.g. complex game mechanism, elaborated contents, and robust graphical representation). To this end, games are not limited to mere entertainment products, but micro digital worlds in their own rights that the players can interact and even experiment with in different ways.

6.9 The aspect of economic and financial incentives can be used to draw participants into the environmental problems

Similar to the link between socio-environmental issues highlighted above, the aspect of economic and financial incentives too, appeared to be quite effective in drawing the participants into the environmental issues.

For example, a number of participants have referred to the concept of smart products[6] presented in the learning mediums. Many participants who referred to the smart products did so mainly in appreciation of the convenience and the long-term financial benefits provided by these products. As Keller (2010: 45) has pointed out the connection between the learners' goal and the learning efficiency, it is reasonable to assume in this case that many participants were motivated by the perceived personal benefits rather than ecological ones.

The major gap remains, however, in that some participants have critically expressed their concern about technological items (e.g. the capital cost, the return of investment, the risks, and other technical concerns). This gap highlights that it is necessary for the governments and other responsible institutions to provide comprehensive information on technological products in order to clarify these concerns as well as to promote the use of sustainable products / technologies.

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[6] These are innovative and sustainable household technologies highlighted in the leaning mediums that can be used to improve the quality of life as well as minimize environmental pollutions.

6.10 The aspect of social implications can be used to draw participants into the environmental problems

As discussed in the GEG chapter, Rothschild (1999) and Rose (2009) suggested that the social aspects such as health and financial benefits from the environmental conservation can be used to encourage non-environmental conscious audience into the environmental conservation topics.

In supporting the theories above, participants' statements suggested that a number of participants recognized and / or linked the environmental issues to the social issues. For example: a participant has referred to the hardship from the lack of water during the draught season while referring to the concept of water conservation. In another example, a participant has linked the illegal logging issue with the illegal profits used by the criminal organizations (the link between environmental destruction and criminal organizations was not presented in the game / reading material).

6.11 Reflecting the game events to other real-world events

A number of responses have indicated that many participants have linked the content from the game to other real-world events. For example, a participant has linked the concept of food safety in the learning medium to a recent report of food poisoning in school children caused by unsanitized food preparation).

In these cases, the learning medium(s) act as 'reminders' for the participants – helping them recalled on similar information / events that they might have encountered previously.

Further, some participants have linked the content from the learning mediums to personal experience (e.g. linking water pollution to a personal experience of illness caused by water contamination).

A point of interest can be found during the interview where several participants have indirectly disclosed their association with countryside lifestyles, scientific backgrounds, and agricultural backgrounds. Participants from these backgrounds appeared to reflect on the socio-environmental issues more critically when compared to other participants. They also appear to value the importance of the natural conservation and discuss the methods that could be used for environmental conservation extensively. Arguably, their reflective thinking and pro-environmental intentions may have originated from their backgrounds. This finding is partially supported by Coyle (2005) who highlighted that the outdoor activities can contribute to environmental awareness.

6.12 Behavioural intentions: the overall poor responses towards pro-environmental actions

Despite the knowledge improvements for both study groups after using the learning mediums, participants' interview statements have shown that the majority of participants' behavioural intention did not change towards pro-environmental behaviours / attitudes after using the learning mediums.

For example, when all participants were asked with the ultimate question: "Would you agree with the concept of pollution tax?", the majority of participants (89.47%) have rejected / partially declined to support the policy – indicating that the majority of participants have declined / reluctant to sacrifice their financial resources for the environmental conservation efforts.

Further, the response was not remarkably differed for both study groups – with the disagreement rate of 83.78% from the experimental and 94.87% from the control group. The result indicated that THE GROWTH was no better than the reading material in term of motivating the participants towards pro-environmental behaviours[7].

Moreover, other 'specific followed-up questions' designed to investigate participants' behavioural intentions / attitudes towards the pro-environmental actions did not yield pro-environmental outcomes in many cases.

For example, the majority of participants from both study groups who have recalled about the forest conservation have expressed that they do not wish to donate for environmental conservation projects. This finding is similar to the concept of pollution tax mentioned above where many participants have declined / reluctant to sacrifice their financial resources for the environmental conservation projects.

Similarly, the majority of participants who have recalled about the public transportation have responded that they would drive private vehicles (or driving as well as using public transports) if provided with the free fuel – indicated that the personal convenience was more important than environmental conservation.

However, the majority of participants who have recalled about technological devices (e.g. solar technology, energy / water efficient technology, and other smart products) have shown their interests to invest in these technologies. Two possible explanations are that:

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[7] However, it should be noted that the reading material used in this study was basically a non-interactive version of THE GROWTH. Thus, the comparison between THE GROWTH and other types of reading materials might be able to produce different behavioural intention outcomes. Further, comparison could be made by comparing the learning outcomes from the participants using the game with participants reading the same content from the digital tablets (usability observation). This could be a topic of interest for the future study.

- Unlike sorting garbage for recycling or committing to sustainable consumption, many technological devices represent automated systems, requiring minimal human inputs (i.e. minimum or no efforts required).
- Many technological devices can contribute to long-term financial benefits (e.g. solar technology and smart sockets), promote convenience (e.g. automation), or both.

6.13 The resistance towards pro-environmental actions & the real-world social obstacles

While both THE GROWTH and the reading material appeared to increase participants' knowledge and awareness on environmental, social, and technological issues, social constrains appeared to influence the participants' behavioural intentions as indicated by their responses.

It appeared that the rejection of the concept of pollution tax for some participants was originated from the social and real-life obstacles such as: the lack of trust in governmental transparency and the lack of cooperation from other groups / countries (i.e. 'others are not doing enough').

For a number of participants, their disagreements with the concept of environmental / forest donation appeared to stem from the issues such as: 1) the forest conservation is the duty of the government and the law enforcement, 2) the perceived corruption and inefficient forest management, and 3) the negative attitudes towards the environmental organizations.

Similarly, apart from the notion of inconvenience, a number of participants have rejected / partially rejected the use of public transports based on the safety and accessibility issues.

6.14 The usability survey results (QUIS) informed that the majority and / or a number of participants from the experimental group were satisfied with their experiences on THE GROWTH – highlighting THE GROWTH's value as an attractive environmental learning medium

As discussed in the findings chapter (also see the QUIS on the appendix section), the majority and / or a number of participants from the experimental group have rated THE GROWTH highly in term of overall user interaction. Further, other game mechanisms have also received a relatively high rating from the participants – suggesting that the overall game design of THE GROWTH was well-received by the participants.

Participants, however, have criticized certain design aspects of the game such as the inability to use shortcuts, the inability to undo the recent action, and the inability to customize the game parameters.

From the interview, several participants have also provided extensive feedback about the game. These include the expansion of game content and the additional uses of animation. These

valuable feedback will be realized in the next iteration of THE GROWTH (please see the appendix section for the future development of THE GROWTH).

6.15 Participants' expectation for the government to protect the environment and the society

During the interview, a number of participants have expressed that they expected to see the government taking active roles in the environmental and social management. For example, the law enforcement and the penalty were cited by many participants as the means to deter the environmental and social crimes. Also, emerged from several participants' statements were the corruption problems which considered by many participants as an obstacle for the environmental and the social development.

According to participants' statements, other environmental issues that require governmental actions include facilitating the recycling operation and regulating the traffic rules to increase the efficiency of the public transportation. These highlighted the gap between the theoretical environmental models presented in the learning mediums and the obstacles in the real-world.

6.16 The roles of religions and beliefs on the environmental and social issues

The content in both learning mediums did not link religious and local beliefs to the context of environmental and social issues in order to avoid possible alienation. Few participants, however, have made references to religious and local beliefs while discussing on the environmental and social topics from the learning medium, suggesting that the aspect of religious and local beliefs still hold important values, at least for some participants.

On the other hand, the introduction storyline for the control group participants was presented in the reading material from page 23-30 (the second section after the socio-environmental facts section). Although the direct observation couldn't be used for the control group, it is assumed that many participants did not view the content from this section.

6.17 Incorrect / incomplete information[8]

As mentioned earlier in the GEG chapter, Ambrose et al. (2010: 10) has highlighted the impact of misconception in learning. In this study, the researcher has detected few cases where the participants have made incorrect / incomplete statements on topics recalled during the interview (5 cases; 4 from the experimental and 1 from the control group).

For example, a participant has mentioned about the advantage of bio-plastic that might one day replace the petroleum-based plastic and reduce the environmental pollution. However, the participant did not mention about the environmental implications associated with the production of bio-plastic (e.g. the energy used in the production of bio-plastic and the rebound-effect of plastic consumption). It was unclear whether the participant was aware of these implications or not.

In another example, a participant has referred to the electric vehicles as an 'environmental-friendly' transport option, but did not mention the fact that the majority of electrical production in Thailand was generated from the fossil-fuel sources.

In another example, a participant has demonstrated her awareness on the desalination technology and citing it as an instrumental technology for water shortage problem. However, the participant did not elaborate on the environmental impacts from the excessive release of saline solution into the ocean as well as the aspect of extra energy consumption[9].

In yet another example, a participant has initially questioned the small amount of children per family (or no children at all) as promoted in the game. During the discussion with the researcher, however, the participant has come to realize the importance of children's well-being despite the fact that the context was already presented in the reading material.

The examples above suggested that the incorrect / incomplete information issues may occur while using the learning medium. It also highlights the importance of the facilitators who could clarify / provide extra information to the learners (for traditional classroom-based setting). Alternatively, online communities (e.g. online forum) could provide a debate arena for the learners where insightful information can be presented and discussed by members of the gaming community and the subject experts.

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[8] To maintain the objective of the interview session, incorrect / incomplete information was not clarified with the participants until the end of the session.

[9] However, the participant has later demonstrated her understanding of renewable technology by suggesting that off-peak energy could be used to run the desalination facility where water could be stored for further use.

6.18 Participants' awareness on the experimentation & the researcher's influence on participants' recall ability during the interview

The variation in emotional outcomes between using games in the laboratory and the natural setting (e.g. home) was noted in a study (Takatalo, Häkkinen, Kaistinen, Nyman 2010). The artificial nature of the experimentation may allow the participants to develop the 'test-awareness' (i.e. developing repulsive or competitive attitudes for knowing that their performances will be tested). This means that the learning outcome might be differed if the game was deployed in the natural setting.

The overwhelming majority of the participants were either university-level students or workers with at least bachelor degree qualifications. Thus, they might be familiar and aware of the research design to some extends. This highlights the validity issue as the experience of playing the game in an artificial setting (e.g. lab-based) can be differed from playing at one's pleasure (e.g. at private space, without being monitored, and without being subjected to certain experimental procedures).

Data mining software (e.g. game analytics) might be useful in helping gather players' information in a less-intrusive manner. However, consent statements still need to be agreed by players for ethical reasons and the awareness of being monitored silently may still affect players' performances (e.g. choices made in the game). Additionally, a number of households in Bangkok (and Thailand) are not equipped with the cable internet, limiting the use of online game analytic matrices.

6.19 Knowledge retention: the lack of delayed post-test

The post-test was conducted in the same session. Although all participants appeared to gain additional knowledge after using their respective learning mediums, the limitation of this experimental design lies in its inability to demonstrate participants' knowledge retention over the period of time.

To this end, it is important for the future work to include the delayed post-test into the next experimental design in order to investigate and compare the knowledge retention of gaming participants to other learning mediums.

6.20 Conclusion

In this chapter the researcher has discussed the implications and limitations to the interpretation of findings. The next chapter will be the conclusion of this study where the main findings will be aligned with the three main research questions raised in the first chapter.

7. Conclusion

This study explores the plausibility of using a digital serious game in the environmental learning context. As the environmental issues worldwide appeared to be originated from human activities, this study used the unsustainable growth of human population as the central theme.

Thailand's deteriorating environmental and social conditions justifies the enlistment of population in the country as prospective participants (e.g. diminishing wildlife and forest lands, inadequate resources and waste management, and the relatively high unplanned pregnancy rate).

The innovative game technologies and the perceived shortcomings of games being used in the environmental education have been discussed. As highlighted by the literatures, the boundary between the serious games and the commercial entertainment games are being soften (i.e. entertainment games can contain educational values and the serious games can be entertaining at the same time). Thus, the innovations of game developments from both camps were considered in this study.

In recognition of the shortcomings in existing environmental games, this study proposes a guideline for the development of environmental games called 'A Guideline for Environmental Games' or GEG. GEG aims to inform other researchers of the key game elements and options that should be considered for environmental games development. GEG was inspired by the recent innovations in game theories, learning theories, and persuasion theories.

To evaluate GEG's educational and motivational values, THE GROWTH – a prototype environmental game with a special focus on the growing human population issue was developed based on the GEG. 82 Thai-nationality participants have participated in this study. Participants were randomly assigned into either the experimental group (using THE GROWTH) or the control group (using a traditional non-interactive reading material with identical textual & graphical information to THE GROWTH). The blocked design allowed the researcher to distribute participants into each study group evenly.

The result shows that the experimental group obtained higher average post-test score when compared to the control group. The result also appears to be statistically significant as performed by the two-way repeated measure ANOVA. Additionally, the experimental group was able to recall and discussed more topics presented in THE GROWTH than the control group recalled and discussed topics from the reading material. The result also appears to be statistically significant as performed by the independent t-test. Thus, these findings provide an answer to the first research question that a single-player digital game appears to be an appropriate learning

application for the players to gain insight about the relationship between the growing human population and the environmental issues.

The female participants assigned to the experimental group obtained lower post-test score when compared to the male group. However, the small number of female participants in this study (12) limited a meaningful generalization of the result. Additionally, the females of the experimental group's lower post-test score could be attributed to their gaming orientation and gameplay styles (e.g. the dislike of strong visual presentation and the game setting).

The two-way repeated measure ANOVA indicated statistically significant difference in post-test scores between age group. Contrary to the expectation that the younger age group would be motivated by the digital game-based learning application, some younger age groups in this study did not obtain higher post-test score when compared to some older age groups. This inconclusive finding, however, may rest upon the number of reasons:

For example, the gameplay observation indicates that each participant has his / her own gameplay style (also true across age groups). While some participants have focused on the quiz game function, others did not concentrated on the quiz function and simply browsed for the textual / graphical content in the game. Thus, the limited interaction with the quiz function may have contributed to the lower post-test scores of some participants (as the quiz function is the central game mechanism where the core learning activity occurred).

Although a number of older age groups participants obtained relatively lower post-test scores when compared to younger age groups participants, interview sessions have revealed that the amount of topics recalled and discussed by many older age groups participants was on par with the younger age groups. Additionally, many older age groups participants were able to reflect on the recalled topics more critically and in greater details when compared to some younger age groups participants.

Although the majority of participants did not disclose their personal information such as occupation, education, and income level, some participants have indirectly disclosed about the nature of their works / business, their association with the natural environment (e.g. agriculture, social responsibility, and tourism), and their responsibility over the utility expenditures. A number of these participants were able to reflect on the recalled topics during the interview in detail – indicating the link between personal experience and the reflective learning / thinking level.

On average, participants from the experimental group appeared to spend longer time on the learning medium (THE GROWTH) when compared to the control group (who use the reading material). As observed from the recorded gameplay, the longer time that the participants spent on the game did not appeared to be associated with usability or technical issues. This finding indicates that THE GROWTH may have a greater effect on intrinsic motivation when compared to the non-interactive reading material. This finding is reinforced by the QUIS analysis where the experimental group participants have rated their overall experience with THE GROWTH more positively when compared to the control group participants' ratings on the reading material (e.g. in satisfaction and stimulation category). These findings provide a second answer to the first research question that a single-player digital game appears to be an attractive learning application for the players.

However, it's worth to note that the correlation between the time that the participants spent on the learning mediums (i.e. time-on-task) and the post-test scores was not statistically significant. In other word, the longer time that the participants spent on the game / the reading material did not guarantee a greater knowledge score outcome.

To answer the second research question on the game elements influencing the learning and motivational outcome, a number of game elements appeared to influence the learning and motivational outcomes as observed from THE GROWTH's recorded gameplay and the interview. However, it is worth to note once more that THE GROWTH was designed to be played over an extended period of time (similar to other city management games) whereas each experimental session was limited to less than two hours. Therefore, the educational and motivational values of certain game elements may not be realized fully in this current study.

The main component influencing the knowledge outcomes (factual knowledge) appears to be the quiz game function and the instant feedback system. It was observed that a number of participants who have made mistakes on certain quiz questions were able to correct their mistakes in the subsequent encounter with the same quiz questions.

Some participants appeared to enjoy reading the textual entries accompanying game objects. These entries were later recalled and discussed by the participants during the interview. A large number of participants appeared to be interested in technological topics (e.g. sustainable technologies and renewable energy technologies). This highlights that environmental-friendly technologies should be promoted in the environmental game, but care must be taken to portray both the benefits and the limitations of these technologies thoroughly.

As predicted, some participants appeared to be interested in the financial / economic incentives offered by the new technologies and the environmental conservation efforts. This highlights that the financial and economic factors should be presented in the environmental game to address environmental issues in a 'neutral' light and to counter the effect of 'environmental-only model'.

A number of participants also appeared to be interested in the social topics. Many participants have discussed, criticize, and defend their viewpoints vigorously during the interview. Some participants were able to link the environmental with social issues during the interview (e.g. law and corruption, environmental crimes, cultural values, and health issues). This finding indicates that the inclusion of social aspect into the environmental game may allow the players to see relationship between the natural environmental and the society.

By including both the local and global issues into the game, some participants were able to compare certain issues in Thailand to other countries. This finding indicates that the presentation of both the local and international issues allows the participants to compare and understand the environmental and social issues around the world.

Some participants have cited the empowerment and the dynamic gameplay as the 'fun' part of the game (e.g. the ability to acquire new buildings and customize them, the interaction between game elements, and the random elements). Therefore, these game elements appeared to be the

motivational factors for some players. Although these game elements are also the common elements in many other games, the researcher once again emphasizes that care must be taken in order to interpret these game elements in the environmental learning context[1].

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[1] For example, the benefits of using the robots (i.e. drones) in the forest conservation project could be offset by the high initial cost, the reliance on the communication system, and the risk of malfunction. Similarly, the long-term economic benefits from the forest conservation could be portrayed as a slow, but steady income as opposed to the fast, albeit short-term benefits the players might receive from the deforestation.

For the third research question, both THE GROWTH and the reading material's ability to encourage the participants towards pro-environmental actions / behaviours appeared to be limited.

The majority of participants from both the experimental and the control group have declined to support the concept of pollution tax. Similarly, many participants have declined to support and / or responded tentatively to other pro-environmental actions where the financial and / or economic incentives are absent or limited (e.g. donations for the forest protection projects and recycling).

Some of the reasons, as asserted by the participants, have rested in many socio-political issues such as accessibility, safety, convenience, and perceived corruption and inaction from both the government and the corporations. Predictably, other participants have cited time and efforts as the main obstacles.

In summary, the findings from this study indicated that THE GROWTH can increase the participants' knowledge on environmental and social issues related to the unsustainable growth of human population. As THE GROWTH was based on the Guideline for Environmental Games (GEG), this highlights the educational and motivational values of the guideline. Additionally, the game appeared to have a greater learning effect when compared to the traditional non-interactive reading material with a similar content. By using a systematic study design (RCT), this finding fortifies the digital game based learning (DGBL)'s ability in supplementing the traditional environmental education.

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A Guideline for Environmental Games (GEG) and a randomized controlled evaluation of a game to increase environmental knowledge related to human population growth

By

Charn Pisithpunth

PhD

Vol. 2

November 2015

A Guideline for Environmental Games (GEG) and a randomized controlled evaluation of a game to increase environmental knowledge related to human population growth

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Vol. 2

November 2015

A thesis submitted in partial fulfilment of the University's requirements for the degree of Doctor of Philosophy

Table of contents: Volume 2

Certificate of Ethical Approval

Applicant:

Charn Pisithpunth

Project Title:

THE GROWTH

This is to certify that the above named applicant has completed the Coventry University Ethical Approval process and their project has been confirmed and approved as Medium Risk

Date of approval:

13 November 2015

Project Reference Number:

P23678

Appendix 01: Descriptive statistics of outcome variables.

Figure: The bar chart showing pre-test score, post-test score, and score improvements (post-test minus pre-test score) between the experimental and the control group.
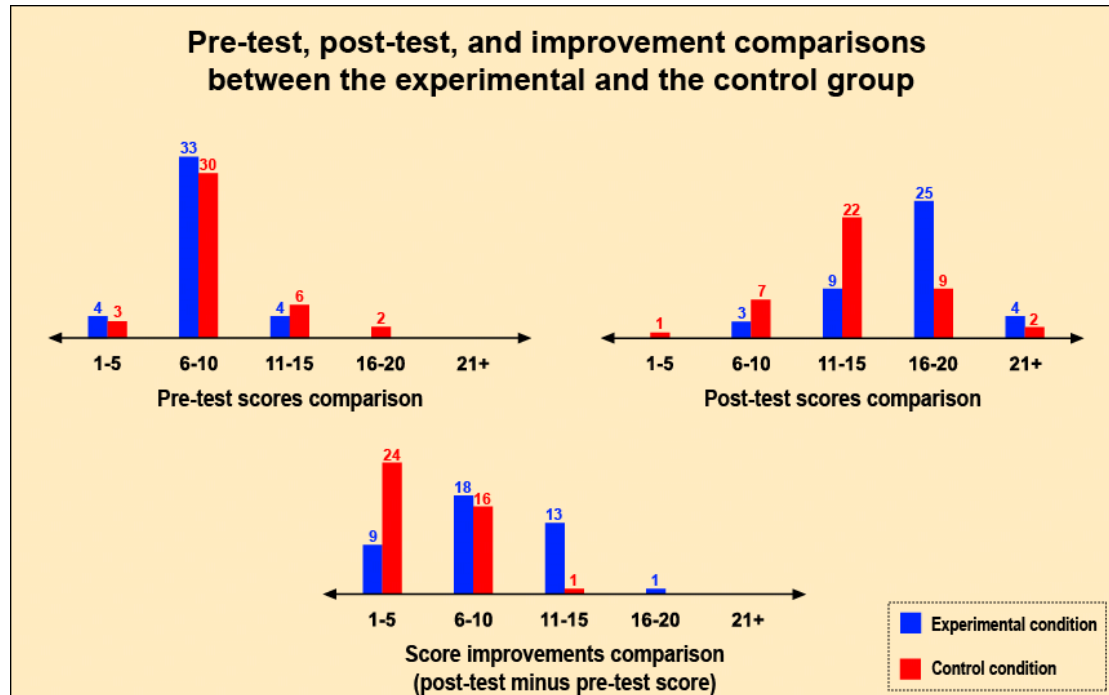
As shown in the figure above, the score outcomes (i.e. knowledge outcomes) can be grouped into 5 categories. These being: very low (1-5 or 4.35-21.74%), low (6-10 or 26.09-43.48%), medium (11-15 or 47.83-65.22%), high (16-20 or 69.57-86.96%), and very high (21+ or 91.30-100%).

As shown in the figure above, the pre-test score was not remarkably different between the two study groups. The pre-test scores between the two study groups were not statistically significant as performed by the independent-sample t-test (Experimental group: M = 8.20; SD = 1.96 VS Control Group: M = 8.83; SD = 3.21); t (80) = 1.0792, p = 0.28.

The majority of participants from both the experimental (80.49%) and the control group (73.17%) having 'low' score outcomes in the pre-test (i.e. only 6-10 questions have been answered correctly). Only 4/41 participants (9.76%) from the experimental group and 6/41 participants (14.63%) from the control group obtained 'medium' scores. Further, only 2/41 (4.88%) of participants from the control group obtained 'high' scores.

The pattern of scores, however, changed in the post-test. The same set of test conducted immediately after the participants had used the game / reading material.

The independent-samples t-test shows a statistically significant difference in the post-test scores for the experimental group (M = 16.63; SD = 3.55) and the control group (M=13.32, SD=3.76); t (80) = 4.1097, p = 0.001. The result indicated that the participants who play THE GROWTH learned more about the environmental and social issues when compared to the participants who used the reading material.

Additionally, the independent-samples t-test shows a statistically significant difference in the score improvement (i.e. pre-test score minus post-test score) for the experimental group (M = 8.66; SD = 3.71) and the control group (M=4.56, SD=2.39); t (80) = 5.9442, p = .001, with the experiment group showing significantly more improvement in their knowledge scores compared to the control group.

Table: The descriptive statistic of pre-test score, post-test score and, score improvements for participants in each study group (post-test minus pre-test score).

Experimental Group (N=41)			
Central tendency / Dispersion	Pre-test	Post-test	Improvements
Mean	8.195	16.634	8.415
Median	8	17	8
Mode	8	17	8
Range	8	14	13
Standard Deviation	1.964	3.547	3.398
Variance	3.860	12.587	11.548
Control Group (N=41)			
Central tendency / Dispersion	Pre-test	Post-test	Improvements
Mean	8.756	13.317	4.560
Median	9	13	4
Mode	6, 9	12	6
Range	7	15	10
Standard Deviation	3.238	3.757	2.387
Variance	10.489	14.121	5.702

Appendix 02: The pre- and post-test result comparison between the two experimental phases

As mentioned earlier in the methodology and procedure chapter, the researcher carried out two experimental phases at different time for this study (40 participants in the first and 42 participants in the second phase). The result obtained from both experimental phases at different time can indicate the consistency of the findings in term of knowledge attainment.

Table: Pre-test score comparison between treatment groups & phases

Pre-test score comparison between study groups & phases				
Study Groups & Phases	N	Mean	SD	VAR
1st Phase Experimental	20	7.90	1.77	3.15
1st Phase Control	20	7.35	2.16	4.66
2nd Phase Experimental	21	8.47	2.14	4.56
2nd Phase Control	21	10.10	3.56	12.69

As shown in the table above, the average pre-test scores comparison within the same study group from both phases was not remarkably differed from each other. The result is also not statistically significant as performed by the independent t-test.

Table: Post-test score comparison between treatment groups & phases

Post-test score comparison between study groups & phases				
Study Groups & Phases	N	Mean	SD	VAR
1st Phase Experimental	20	16.15	3.86	14.87
1st Phase Control	20	11.75	3.41	11.67
2nd Phase Experimental	21	17.10	3.25	10.59
2nd Phase Control	21	14.80	3.52	12.36

In the post-test, however, the experimental groups from both phases gained higher average scores when compared to the control groups from both phases. The 2nd phase experimental group gained slightly higher average post-test score when compared to the 1st phase experimental group.

The 2nd phase control group gained higher average post-test score when compared to the 1st phase control group. Interestingly, the post-test score for the 2nd phase control group was only slightly lower when compared to the post-test score of the experimental groups[1].

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[1] It should be noted that 7/21 participants from the 2nd phase control group have obtained relatively high post-test score (17-22 scores)

The score comparison between phases conducted with the two-way repeated measure ANOVA did not yield a statistically significant result $F(1,40) = 3.281$, $p = 0.074$. In other word, the knowledge attainment results between the first and the second phases did not appear to be significantly differed from each other.

Figure: The pre- and post-test score comparison between the experimental and the control group of each phase (the first phase to the left and the second phase to the right).
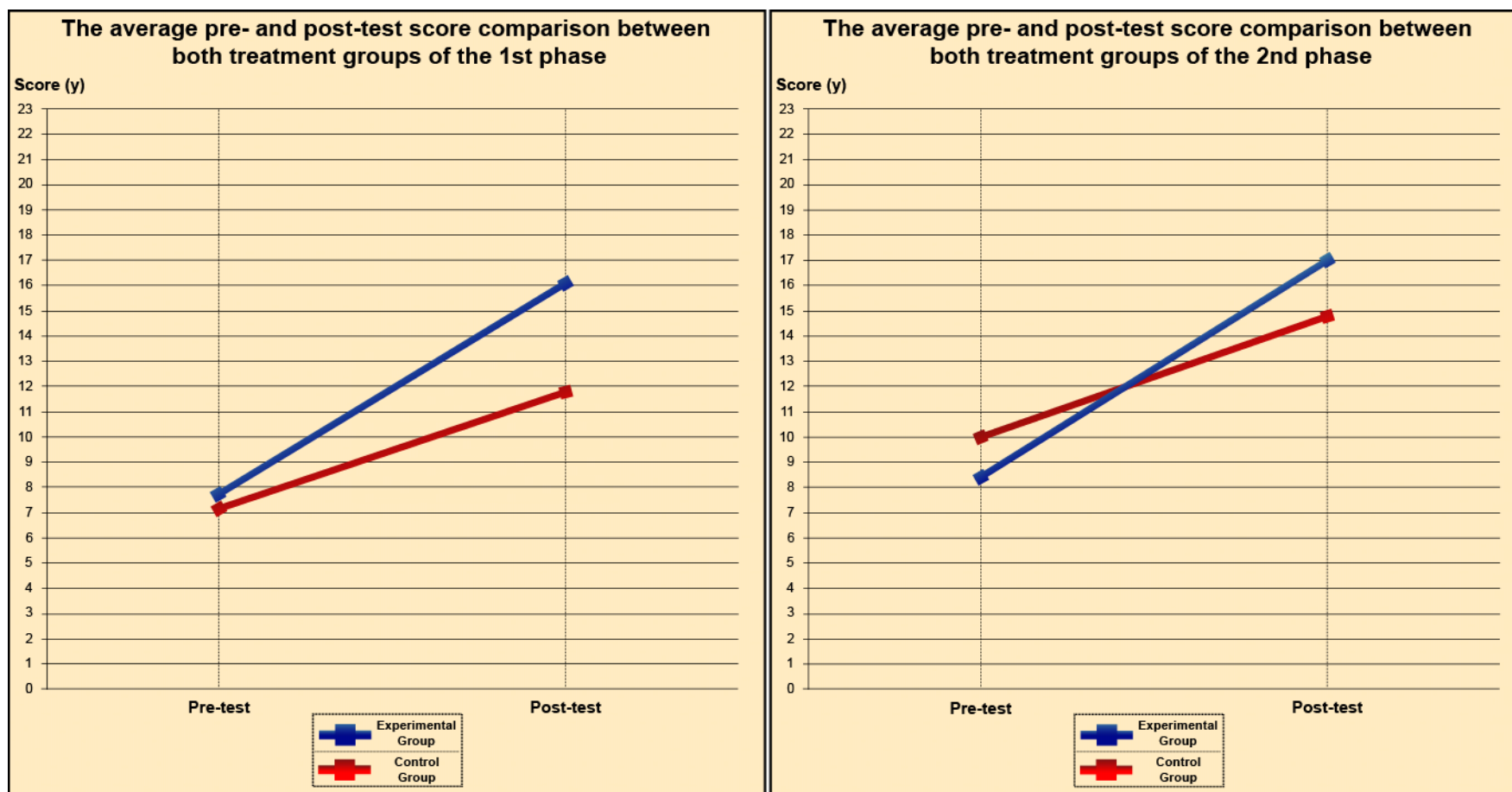
Appendix 03: The pre- and post-test result comparison between locations (laboratory condition VS other locations)

As mentioned earlier in the methodology and procedure chapter, some participants did not partake in the laboratory-based condition due to personal reasons. To this end, experimental sessions with 21/82 participants (25.61%) were conducted in other locations (8 from the experimental and 13 from the control group).

Efforts have been made to arrange for suitable alternative location in order to prevent noise pollution and other distractions. This section compared the level of knowledge attainment between participants underwent experimental sessions in laboratory-based condition (lab-condition) to participants underwent experimental sessions in other locations (non-lab condition).

Table: Pre-test score comparison between study groups & locations

Pre-test score comparison between study groups & locations				
Study Group & Location	N	Mean	SD	VAR
Experimental (in-lab)	33	8.45	1.97	3.88
Control (in-lab)	28	9.35	3.57	12.76
Experimental (other location)	8	7.13	1.64	2.70
Control (other location)	13	7.46	1.90	3.60

As shown in the table above, the average pre-test scores comparison of participants within the same study group was not remarkably differed from each other. The independent t-test was performed to compare the pre-test scores between the lab-condition participants to the non-lab condition participants of the same study group (e.g. lab-condition experimental group VS non-lab condition experimental group).

For both study groups, the independent t-test did not reveal a statistically significant difference in the pre-test result between the lab-condition participants and the participants in other locations (Experimental group: $t(39) = 1.7615$, $p = .086$ / Control group: $t(39) = 1.7915$, $p = .081$).

Table: Post-test score comparison between study groups & locations

Post-test score comparison between study groups & locations				
Study Group & Location	N	Mean	SD	VAR
Experimental (in-lab)	33	16.70	3.44	11.84
Control (in-lab)	28	14.04	3.74	13.96
Experimental (other location)	8	16.38	4.21	17.70
Control (other location)	13	11.80	3.44	11.86

For the experimental group, the post-test scores between lab-condition participants and the participants in other locations were not significantly differed from each other (t (39) = 0.228, p = .82).

For the control group, on the other hand, it appears that participants underwent their sessions in other locations obtained lower average post-test scores when compared to participants underwent their sessions in lab-condition. The result is not significantly differed from each other, however (t (38) = 1.792, p = .07).

The two-way repeated ANOVA suggests a nearly statistically significant result in the difference between participants underwent their sessions in lab-condition and participants underwent their sessions in other locations (F(1,78) = 4.047, p = .048).

To this end, the result indicates a moderate link between the location and score outcomes, with the lab-condition participants appeared to obtain higher score outcomes. This finding is rested upon few implications, however. For example: although efforts have been made to control the surrounding condition of the non-laboratory based environment, the non-standard furniture, the unmanageable faint ambient noises, and the change in ambient temperatures / sunlight might still affected the learning capability (e.g. concentration). Secondly, it is arguable that participants attending their session in the lab-based condition could be viewed as 'more determined' to approach the researcher when compared to non-lab condition participants who were visited by the researcher.

Figure: The pre- and post-test score comparison between the lab-based condition and non-lab condition (lab-based condition on the left and non-lab condition on the right).

Appendix 04: The pre- and post-test comparison between the experimental and the control group (by each question).

This section shows the pre-test, post-test, and improvement scores by each individual question. As mentioned in the methodology and procedure chapter, a set of 23 questions was used in both the pre- and the post-test.

Figure: The pre- and post-test score comparison between the experimental and the control group (by each question). The bars represent test results for the experimental group (dark blue) and the control group (red). 23 questions used in the test can be demarcated into 3 categories: A (green), B (orange), and C (light blue) respectively.
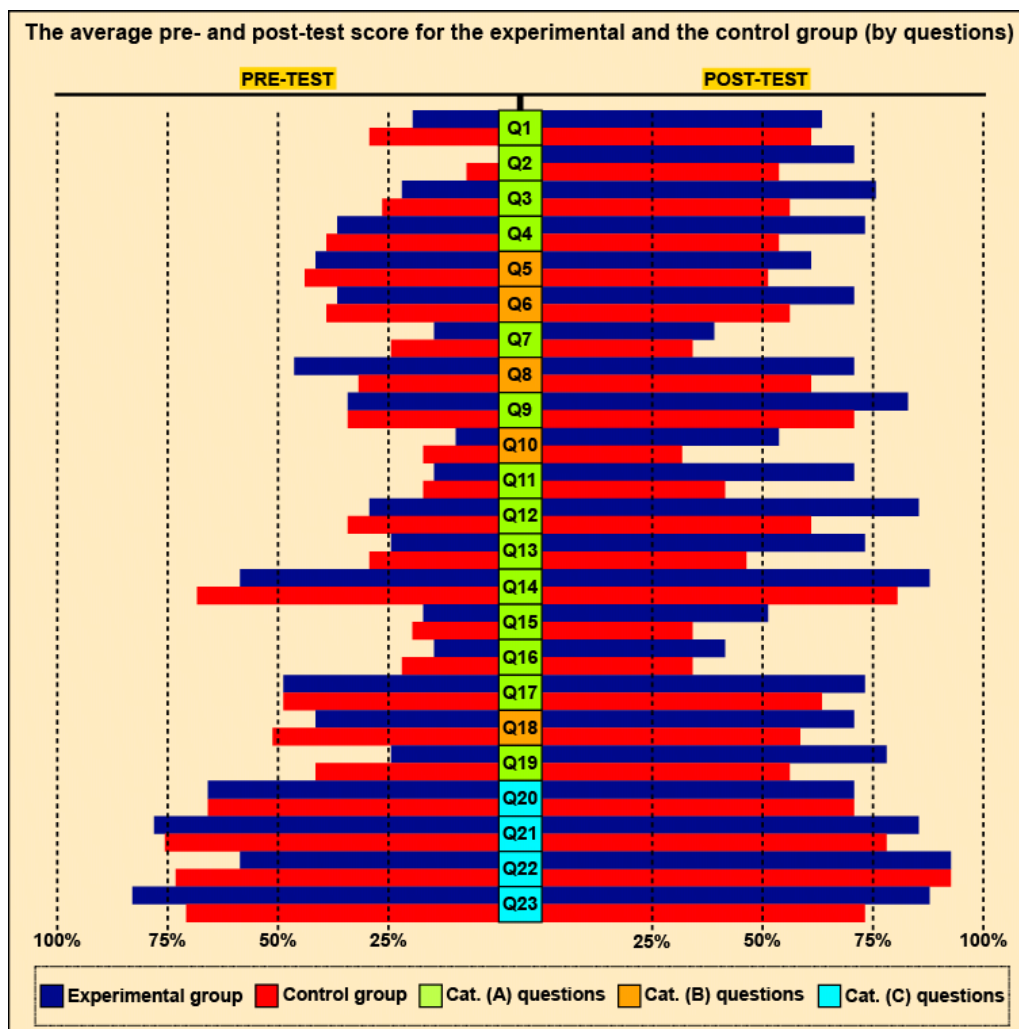
As mentioned earlier in the analysis chapter, 23 questions were deployed in both tests. Test questions can be demarcated into 3 categories. Category-A represents questions testing a single factual knowledge, Category-B represents questions testing multiple factual knowledge, and Category-C represents true-false statement questions.

The pre-test

As indicated in the figure above, more than 50% of the questions were incorrectly answered by the participants (both the experimental and the control group) in the pre-test, indicating participants' limited factual knowledge on the environmental and social issues.

The exception was the Category-C questions (Q20-Q23) where participants managed to obtain high scores (more than 50% of participants from both the experimental and the control group have answered these questions correctly). Whether the relatively higher results from this type of questions were due to their base-knowledge or the smaller chance of error is debatable[1].

Contrary to the prediction, however, there was no significant difference in results between Category-A and Category-B questions. The exception was Q10 which many participants have answered incorrectly[2].

It appeared that the control group participants have slightly outperformed the experimental group participants in 17/23 questions (73.91%).

Only several participants have answered Q2 ("Which region has the most malnutrition and hunger rate?") correctly. Interestingly, none of the participant from the experimental group had answered this question correctly. The majority of participants appeared to recognize Africa as the region with the most malnutrition and hunger rate (Asia and Pacific is the correct answer).

Another point of interest is Q15 ("The majority of global electrical generation is now produced from …"). A number of participants convinced that solar and nuclear powers are the main sources of global electricity.

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[1] Note that with true-false statements, participants have a 50% chance to guess a correct answer as opposed to a 25% chance in other multiple choices questions (multiple choices questions have four possible correct answers).

[2] The majority of participants have either assumed that the majority of global electrical energy was used in the production of ammonia / or have assumed that there was no correct answer in the question – suggesting that many participants were not aware of the environmental impacts from rice production.

The post-test

All participants appeared to gain knowledge attainment in the post-test, with more than 50% of the questions were correctly answered by the participants (both the experimental and the control group). In contrast to the pre-test results, the experimental group appeared to gain greater knowledge attainment than the control group in the post-test. To this end, the experimental group has outperformed the control group in 21/23 questions.

The score improvement

Figure: The score improvement comparison between the experimental and the control group (by each question). The bars represent test results for the experimental group (dark blue) and the control group (red). 23 questions used in the test can be demarcated into 3 categories: A (green), B (orange), and C (light blue) respectively.
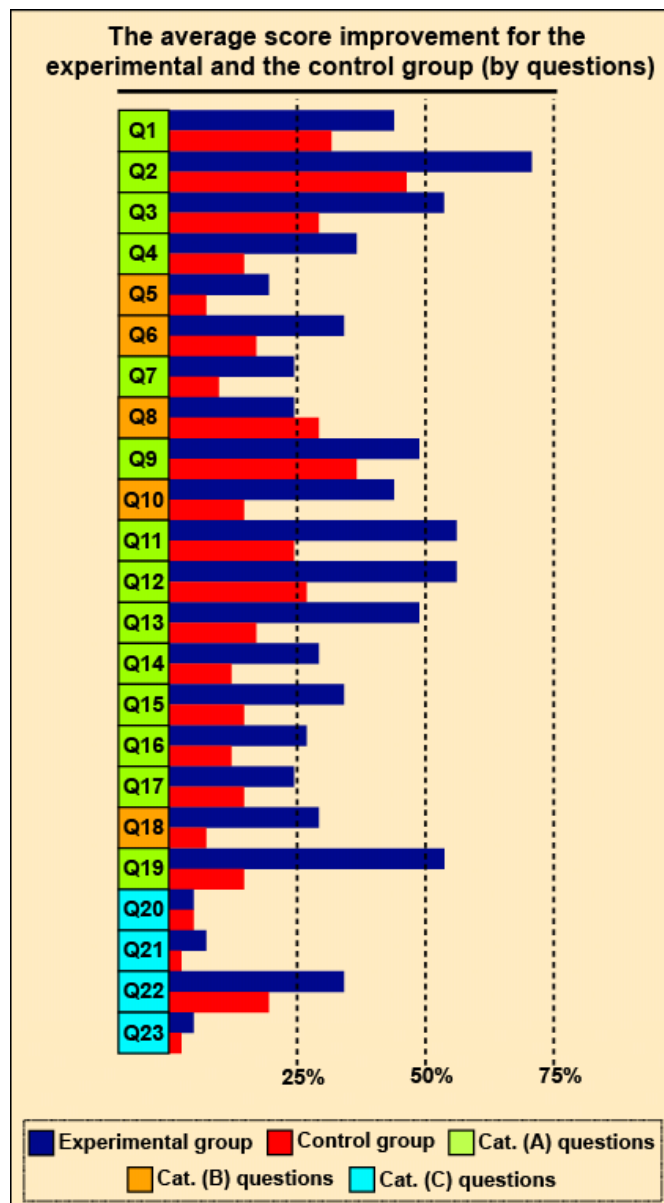
The score improvement (post-test minus pre-test score) indicated that the experimental group has received greater level of knowledge improvement in most questions when compared to the control group. Participants appeared to gain the least improvement on Category-C questions (true / false questions). However, the majority of participants from both groups have already achieved high score from this question category in the pre-test.

Appendix 05: The relationship between the post-test score and time-on-task across age groups and gender groups.

Table: Pre-test, post-test, and improvement score comparison between the gaming and non-gaming groups (by genders).

Gaming males (N=30)				Non-gaming males (N=3)			
Central tendency / Dispersion	Pre-test	Post-test	Improvements	Central tendency / Dispersion	Pre-test	Post-test	Improvements
Mean	8.33	17.30	9.27	Mean	6.33	14.33	4.67
Median	8.50	18	9.5	Median	6	13	5
Mode	8	17	11	Mode	6	9,13,21	3,5,6
Range	8	13	16	Range	1	12	3
Standard Deviation	1.94	3.02	3.33	Standard Deviation	0.58	6.11	1.53
Variance	3.75	9.11	11.10	Variance	0.33	37.33	1.56
Gaming females (N=3)				Non-gaming females (N=3)			
Central tendency / Dispersion	Pre-test	Post-test	Improvements	Central tendency / Dispersion	Pre-test	Post-test	Improvements
Mean	10	16.67	6.67	Mean	7.67	12	4.33
Median	9	17	7	Median	8	14	4
Mode	9	17	5,7,8	Mode	5,8,10	7,14,15	2,4,7
Range	3	1	3	Range	5	8	5
Standard Deviation	1.73	0.58	1.53	Standard Deviation	2.52	4.36	2.52
Variance	3	0.33	1.56	Variance	6.33	19	6.33

The table above shows the pre-test, post-test, and improvement score comparison between the gaming and non-gaming participants assigned to the experimental group (i.e. participants who reported playing games on the daily basis VS participants who reported did not play games on the daily basis).

Note that the scores from 39/41 participants of the experimental group (game group) are presented here. Two (2) participants from the experimental group did not disclose their gaming information and their scores omitted from the analysis. The statistical significance analysis cannot be used to its full potential at this time due to the highly uneven and / or the small sample size in some groups.

However, it is important to emphasize that the significant imbalance in population size between males and females could potentially limits the generalization of this finding.

Appendix 06: The relationship between the post-test score and time-on-task across age groups and gender groups

Figure: The pre- and post-test score comparison between the gaming and non-gaming participants assigned into each study group (the experimental group on the left and the control group on the right).
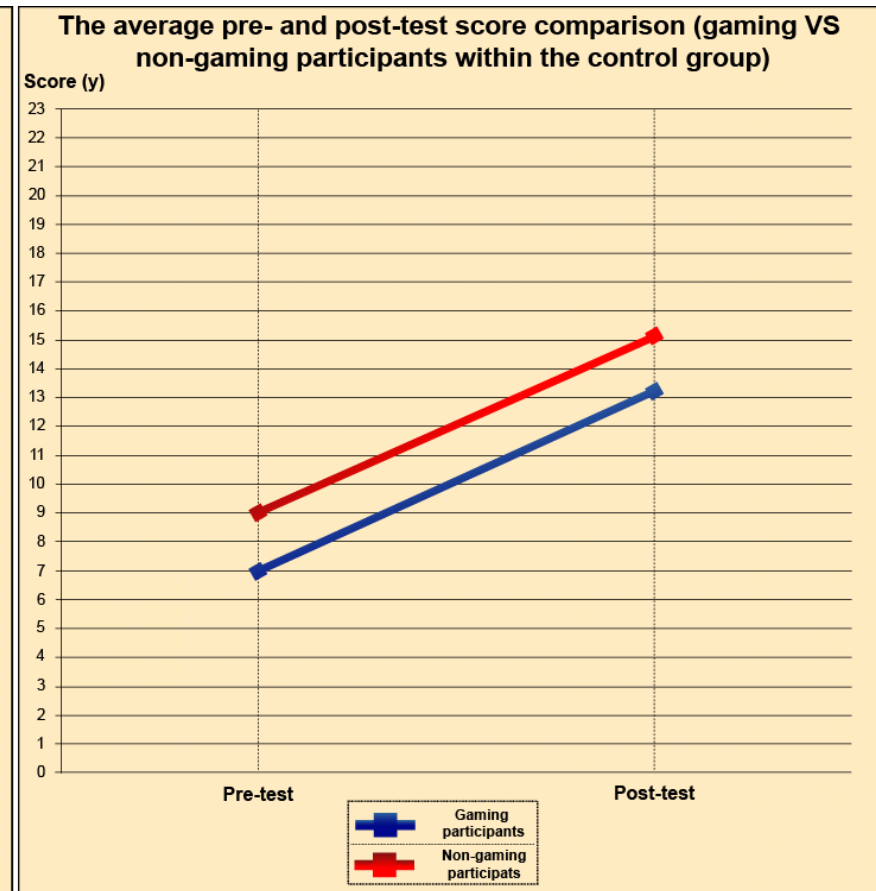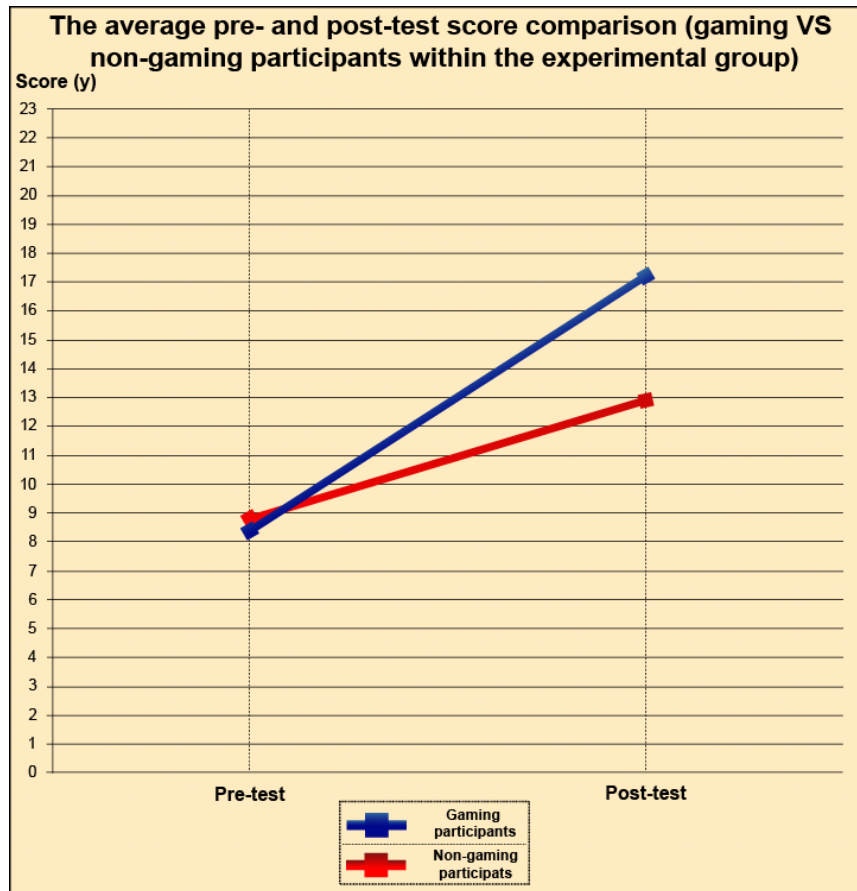
As shown in the figure above, the average pre-test scores for the gaming participants and the non-gaming participants assigned to the experimental group were not remarkably differed from each other. However, the average scores were differed between both groups in the post-test, with the experimental group obtained higher average post-test score. The result appears to be statistically significant as determined by the two-way repeated measure ANOVA ($F(1,78) = 7.592$, $p = .007$).

In other word, participants who reported playing games on the daily basis appear to gain higher knowledge outcomes when compared to the participants who reported not playing games on the daily basis.

On the other hand, the average pre-test scores for the gaming and the non-gaming participants assigned to the control group appeared to be slightly differed, with the non-gaming group obtained slightly higher average pre-test score. Similarly, the non-gaming group also obtained slightly higher average score in the post-test when compared to the gaming group. It should be noted, however, that the higher average post-test score for the non-gaming group of the control study might be attributed to their already higher average pre-test score.

Implications to the interpretation of knowledge outcomes between the gaming and the non-gaming participants

There are several implications for the interpretation of these findings. Firstly, it should be noted that there were only 14 participants who reported themselves as 'non-gamers' (i.e. not playing games on the daily basis). Thus, the major difference in population imbalance between the gaming and the non-gaming participants could potentially limit the generalization of the results.

Secondly, the gameplay observation and the participants' responses from the QUIS survey did not indicate major usability issues for the non-gaming participants. In other word, it was unlikely that the non-gaming participants' lower average post-test score was due to technical and other software learning issues.

Appendix 07: The relationship between the post-test score and time-on-task across age groups and gender groups

1. The relationship between the post-test score and time-on-task across age groups

Figure: The scatterplot showing the relationship between the time that participants spent on the task and the post-test score for participants from different age groups. The blue diamond markers represent results from the experimental group participants while the red diamond markers represent results from the control group participants.

AGE GROUP 26-30

Experimental Group ◆ Control Group

Post-test Score (y)

$y = 0.119 + 13.873 x$
$r = 0.3352$

$y = 0.119 + 11.989 x$
$r = 0.1477$

Time on task (x)

AGE GROUP 31-35

Experimental Group ◆ Control Group

Post-test Score (y)

$y = 0.191 + 7.055 x$
$r = 0.689$

$y = -0.615 + 21.327 x$

Time on task (x)

251

AGE GROUP 36-40

◆ Experimental Group

Post-test Score (y)

y = 0.149 + 10.867 x

Time on task (x)
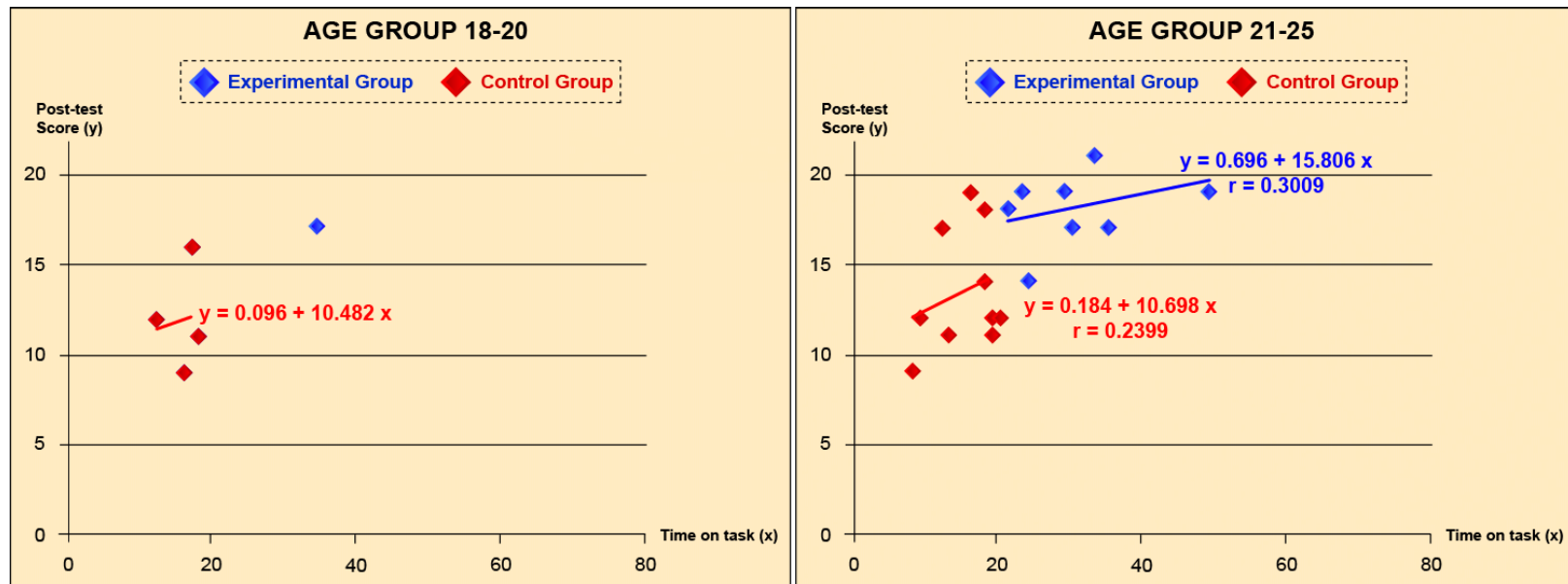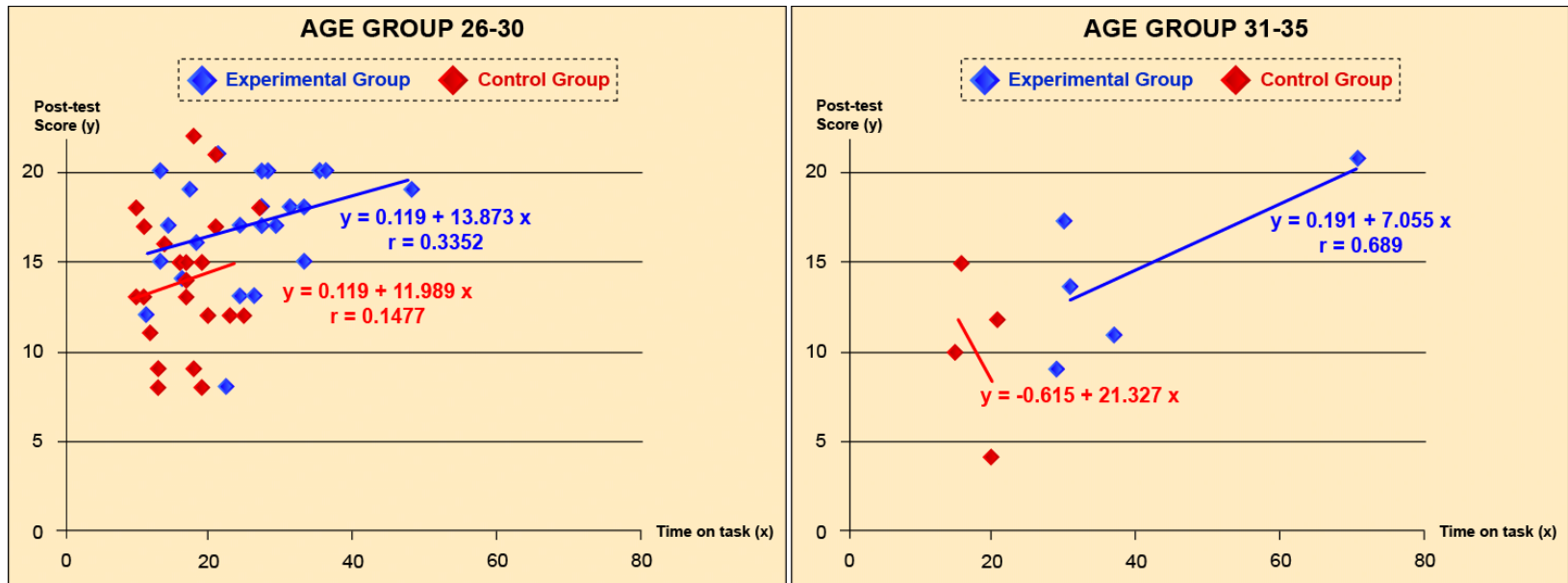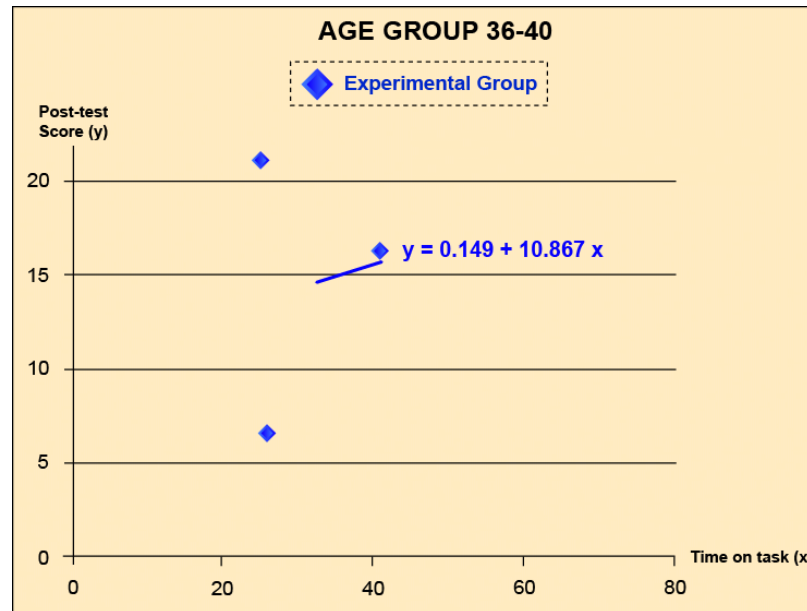
Pearson's r (PPMCC) was performed where possible to determine the correlation level between time that the participants in each age group spent on the task and their post-test scores. The result suggests that there are weak links between the post-test score and the time that the participants spent on the task for all age groups (not statistically significant). In other word, there is no concrete indication that the longer time participants have spent on the task has contributed to the higher post-test score.

The exception, however, is the experimental group of age group 31-35 which shows a moderate link between high post-test score and the longer time that participants spent on the task (r = 0.689), but still not statistically significant (p > 0.05).

However, as with the main pre- and post-test score analysis in the findings chapter, it should be emphasized that the generalization of results cannot be made meaningful in this case due to the small and / or the imbalance population in many age groups (e.g. age group 18-20, 31-35, and 36-40).

2. The relationship between the post-test score and time-on-task across gender groups

Figure: The scatterplot showing the relationship between the time spent on the task and the post-test score for the male and female participants. Pearson's r (PPMCC) was performed to determine the correlation level.
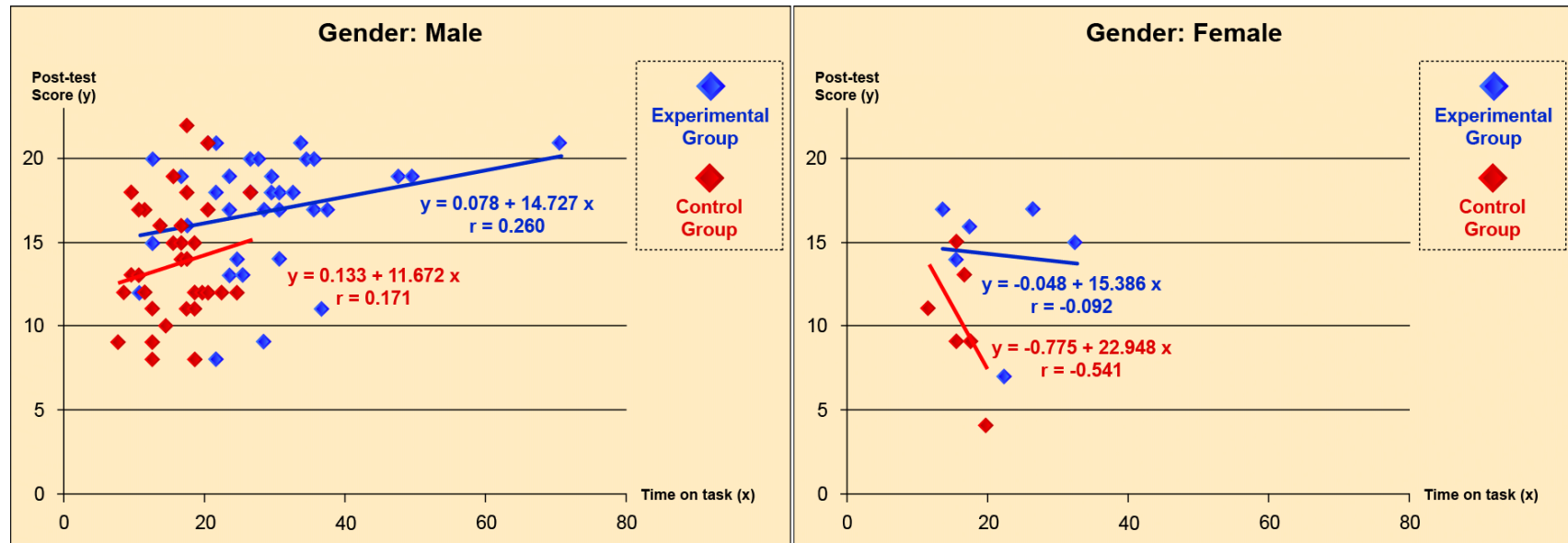
Similarly, Pearson's r (PPMCC) was performed to determine the correlation level between the time that the male and female participants spent on the task and their post-test scores. The result suggests that there are weak links between time that the participants spent on the task and the post-test scores for both male groups (not statistically significant).

On contrary, the result suggests a weak negative link between time that participants spent on the task and post-test scores for the female group of the experimental group. The result also suggests a moderate negative link between time that participants spent on the task and post-test scores for the female group of the control group. These results are not statistically significant, however.

In other word, there is a weak pattern showing that the females of the experimental group who spent the longer time on the task appeared to obtain lower post-test scores – and the same link is more apparent for the females of the control group. However, it's important to emphasize that there was only 6 female participants in each study group and their small size will limit the generalization of results.

Appendix 08: User Interaction Satisfaction / Reader Satisfaction analysis in detail

This section provides a detailed analysis on game usability (for the experimental group) and the readability of the reading material (for the control group).

As mentioned in the methodology chapter, participants were asked to complete the Questionnaire for User Interaction Satisfaction survey (QUIS). This is a questionnaire was designed by The University of Maryland Human-Computer Interaction Lab to evaluate the usability and the reception of digital software (e.g. game).

Participants from the control group, on the other hand, were asked to complete a 'Reader Satisfaction questionnaire'. This is a questionnaire modified from the QUIS with interactivity survey questions discounted since they were irrelevant to participants using the reading material.

All survey questions in both questionnaires have been translated into Thai (the local language).

1. User satisfaction: Experimental group

As mentioned earlier, Questionnaire for User Interaction Satisfaction (QUIS) (The University of Maryland Human-Computer Interaction Lab n.d.) was administered to participants of the experimental group (the game group) in order to understanding participants' experiences / satisfaction with THE GROWTH.

Apart from the QUIS, support evidences from the observation (recorded gameplay) and additional statements from the participants were asserted where possible to provide conclusive results.

Most of QUIS survey questions used 1-9 Likert-scale system. For most questions, rating 1-4 will be considered as low / poor scores. Rating 5 will be considered as medium scores. Rating 6-7 will be considered as medium-high scores while rating 8-9 will be considered as high scores.

After the game, all 41 participants from the experimental group were provided with a survey form (in paper format). Although the amount was not significant, the researcher noted that some participants did not respond to some survey questions. Below are findings from the user satisfaction analysis:

PART 1: Past experience

Computer terminal	6	Keyboard	41
Personal computer	41	Joy stick	31
Laptop Computer	37	Track ball	1
Colour monitor	41	Pen based computing	28
Touch Screen	33	Mouse	38
Floppy drive	29	Graphics tablet	6
CD-ROM drive	41	Head mounted display	3
Modems	24	Voice recognition	2
Scanners	36	Video editing systems	8
Word processor	38	Internet	37
Graphics software	17	CAD computer aided design	17
Spreadsheet software	31	Rapid prototyping system	3
Database software	11	E-mail	40
Computer games	32		

Past experience

In the first part on the 'Past Experience' section, the self-reported data has shown that the majority of participants are familiar with home / office computer devices.

For example: all 41 participants have reported that they are familiar with personal computers, color monitor, keyboards, and CD-ROM drive. 37 participants have reported that they are familiar with laptop computers, 38 participants are familiar with word processor software, and 32 participants are familiar with computer games.

In term of experience with gaming devices and software, the majority of participants (N=32) have reported that they are familiar with computer games. 31 participants are familiar with joysticks and 38 are familiar with computer mice.

Self-reported accounts from some participants have shown that they are familiar with technical equipment and specialized software packages. For example: 17 participants have reported that they are familiar with CAD system, 17 participants are familiar with graphic software, 8 participants are familiar with video editing system, and 3 participants are familiar with rapid prototyping system.

Owing to a large number of experienced computer game users in this experiment and the fact that THE GROWTH was operated on a laptop computer, it was assumed that the participants should

not experience major difficulties in learning and using THE GROWTH since the game was designed on the game principles.

Although the high level of experience on joysticks and computer mice can also be attributed to other non-gaming tasks, support evidences from a separated set of questionnaire has indicated that the majority of participants from both the experimental and the control group are engaging with digital gaming activity on the daily basis (as shown in the participant demographic section within the methodology chapter).
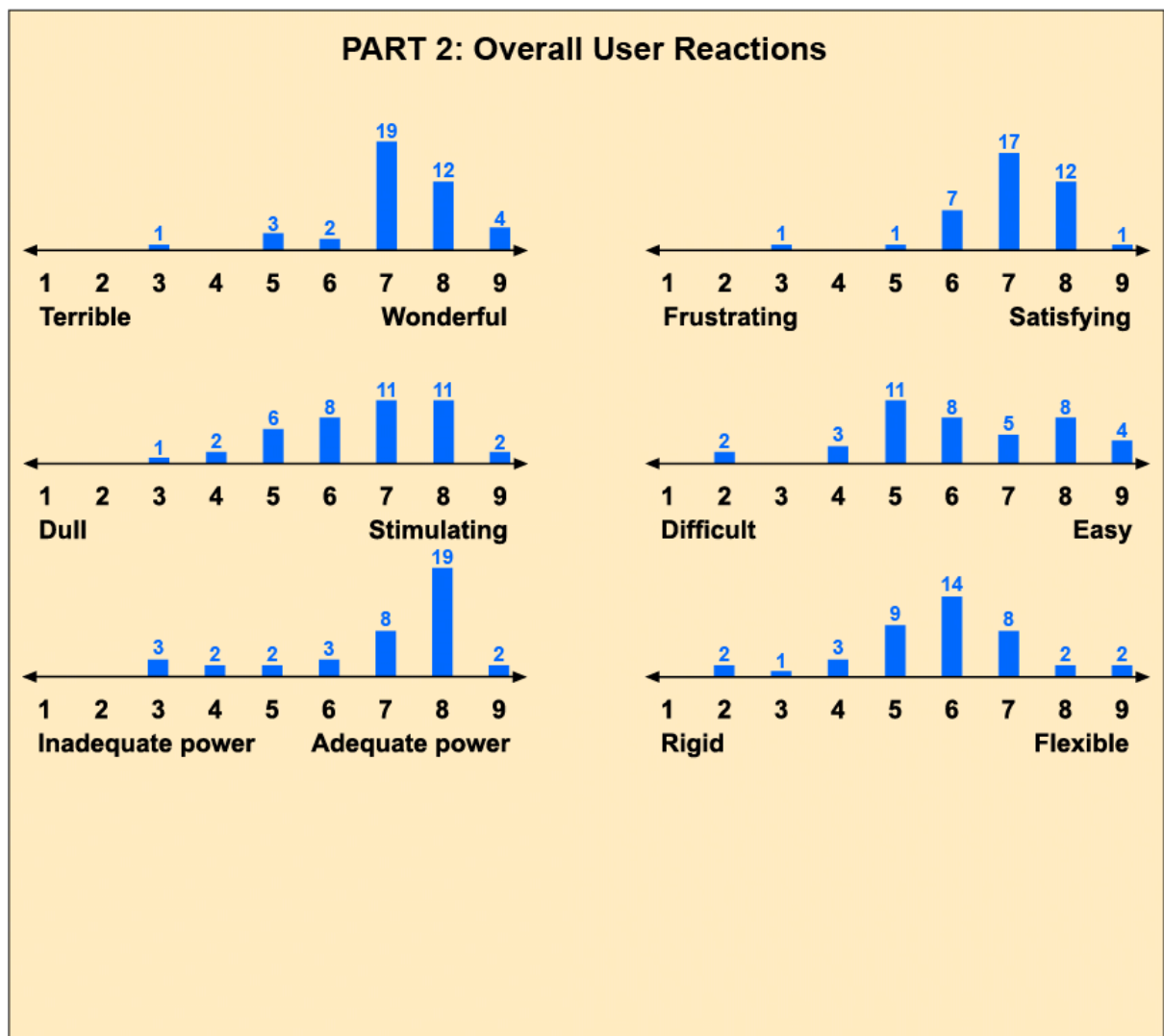
Overall user reactions

In general, THE GROWTH has received positive responses from the majority of participants in term of 'Overall User Reactions' part – with the majority of participants have casted their scores into medium-high (rating 6-7) to high ratings (rating 8-9). The result from this questionnaire part

suggested that the majority of participants considered playing THE GROWTH to be an engaging activity.

However, some sections in this part have received relatively low / medium scores from a fair number of participants. For example: 17/41 participants (about 41.5%) of participants have rated THE GROWTH with either medium or low score in 'Dull-Stimulating' section (rating 3, 4, 5, and 6). This feedback indicates that representation and game mechanism in THE GROWTH could be improved further in the next iteration.

In term of level of difficulty (Easy-Difficult), 5/41 participants have rated the game as difficult (rating 2, 4). 11/41 participants, however, have found the game's level of difficulty to be just right (rating 5). 13/41 participants have found the game to be somewhat easy (rating 6-7) while 12/41 participants have found the game to be easy (rating 8-9).

It's worth to note that few implications are undermining the interpretation of this questionnaire part. Firstly, 'Easy-Difficult' section might be interpreted by the participants as: 1) 'the difficulty in learning game mechanism', 2) 'the difficulty in term of gameplay', or 3) the 'challenging nature of the game'. This issue is related to the misunderstanding of survey questions as demonstrated by Trochim (2006)[1].

Secondly, the majority of participants have played THE GROWTH for no more than an hour and thus, their game progress were still limited to basic game activities such as answering quiz questions (in order to gain in-game resources) or experimenting with low-level upgrades.

Reviews from the recorded gameplay have shown that only few participants have experienced major game events (e.g. disasters) so far. Further, some participants such as #P5, #P6, #P33, #P35, #P39, and #P71 among several other participants – have spent a considerable amount of time exploring the textual and graphical contents in THE GROWTH on their own accords rather than focusing on the actual game activity (e.g. answering quiz questions and resources management).

Participants' responses in 'Rigid-Flexibility' section have also been dispersed. 6/41 participants have rated the game as rigid (rating 2, 3, 4). 9/41 participants have rated the game as neither too rigid nor too flexible (rating 5). The majority of participants (22/41) however, have rated the game as somewhat flexible (rating 6-7) while 4/41 participants have rated the game as flexible (rating 8-9).

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[1] See 'The Qualitative Debate' section on the website.

PART 3: Windows in the System

Chart 1 (top left): Scale 1 (Hard to read) to 9 (Easy to read). Values: 5→1, 6→3, 7→4, 8→15, 9→18.

Chart 2 (top right): Scale 1 (Fuzzy) to 9 (Sharp). (Image of characters). Values: 4→1, 6→1, 7→4, 8→13, 9→22.

Chart 3 (middle left): Scale 1 (Barely legible) to 9 (Very legible). (Character shapes (fonts)). Values: 8→8, 9→31.

Chart 4 (middle right): Scale 1 (Never) to 9 (Always). (System window layouts were helpful). Values: 5→1, 6→2, 7→2, 8→15, 9→21.

Chart 5 (bottom left): Scale 1 (Inadequate) to 9 (Adequate). (Amount of information that can be displayed on system windows). Values: 5→1, 6→1, 8→5, 9→31.

Chart 6 (bottom right): Scale 1 (Illogical) to 9 (Logical). (Arrangement of information that can be displayed on system windows). Values: 5→1, 7→3, 8→17, 9→20.

Reading from the computer screen

To provide participants with optimal gaming experience, care had been taken throughout the entire experimental season to ensure the quality of an LCD monitor (cleanliness, brightness, and connectivity).

The majority of participants (33/41) have responded very positively in term of readability on the computer screen (in 'Hard to read-Easy to read') – and casting their scores into very high rating regions (rating 8-9). 4/41 participants have also responded to this question positively (rating 7).

However, responses from 4/41 participants have indicated that they had some difficulties reading from the screen (rating 5, 6). Reviews from the recorded gameplay have failed to detect any problems with the display, however, and the cause(s) cannot be established.

Character shapes (fonts)

39/39 participants have responded to this question very positively (rating 8-9), indicating that the choice of the main font shape (Arial) in both the game and the reading material was considered adequate by the majority of participants.

Amount of information that can be displayed on system windows

36/38 participants have responded very positively to this question (rating 8-9), indicating that the amount of information displayed on system windows was adequate. Only 2/38 participants have responded to this question moderately (rating 5, 6).

Image of characters

Similarly, while the majority of participants (35/41) have responded positively to this question, the responses from 6/41 participants have indicated that they had encountered some issues with the sharpness of characters' image. In this, one participant had reported a major issue with the sharpness of characters' image (rating 4).

System window layouts were helpful

The majority of participants (36/41) have responded to this question very positively (rating 8-9), indicating that the system window layouts were helpful for the majority of participants. Only 3 participants have casted their scores for this question moderately (rating 5, 6).

Arrangement of information that can be displayed on system windows

The majority of participants (37/41) have responded to this question very positively (rating 8-9), suggesting that the current information arrangement in THE GROWTH was adequate for the majority of participants. 3/41 participants have also responded to this questionnaire positively (rating 7) while only 1/41 participant has responded to this question moderately (rating 5).

PART 4: Learning the System

1 2 3 4 5 6 7 8 9
Difficult   Easy
(Learning to operate the Interface)

1 2 3 4 5 6 7 8 9
Difficult   Easy
(Getting started)

1 2 3 4 5 6 7 8 9
Difficult   Easy
(Learning advanced features)

1 2 3 4 5 6 7 8 9
Difficult   Easy
(Time to learn to use the Interface)

1 2 3 4 5 6 7 8 9
Never   Always
(Tasks can be performed in a
straight forward manner)

1 2 3 4 5 6 7 8 9
Too many   Just right
(Number of steps per task)

PART 4: Learning the System (cont.)

1 2 3 4 5 6 7 8 9
Never   Always
(Steps to complete a task follow
a logical sequence)

1 2 3 4 5 6 7 8 9
Unclear   Clear
(Feedback on the completion
of sequence of steps)

Learning to operate the interface

The majority of participants (28/41) have found the game interface easy to operate (rating 8-9). 10/41 participants have found the game interface somewhat easy to operate (rating 6-7). Only 3 participants have found game interface to be somewhat difficult to operate (rating 4-5).

Learning advanced features

The very first game feature that the majority of the participants have used in THE GROWTH was the 'quiz function' (in order to gather in-game resources). Thus, it is assumed in this analysis that the 'upgrade function', 'investment function', and 'random events' among other game functions (see THE GROWTH chapter) are regarded by participants as advanced features.

The majority of participants (18/35) have reported they can learn advanced features with relative ease (rating 8-9). A fair number of participants (16/35), however, have reported that they have minor problems learning advanced features. No participant had reported significant problems learning advanced features, however.

Tasks can be performed in a straightforward manner

The majority of participants have reported minimum or no problems in performing tasks. 35/40 participants have reported that they can perform tasks in a straightforward manner (rating 8-9).

Responses from few participants (4/40), however, have indicated that they had problems performing tasks in a straightforward manner (rating 4 and 6).

Getting started

The majority of participants have casted their scores in the high rating regions (rating 7, 8, and 9) – indicating that the majority of participants did not encounter major difficulties in getting started.

18/41 participants have reported slight level of difficulties in getting started (rating 7-8). Also, 16/41 participants have reported minimum or no difficulties in getting started. However, getting started can be very difficult for few participants (2/41). 5/41 participants have also reported they have encountered moderate level of difficulties in getting started (rating 5-6).

The amount of time participants have spent on gaming activity on the daily basis might help some of them in getting started. Recorded gameplays have shown that participants who have reported to play games on the daily basis (e.g. #P1 and #P30) can familiarize themselves with THE GROWTH's game mechanism in a relatively short time when compared to other non-gaming participants.

However, some participants (e.g. #P24 and #P35) have also reported they did not have significant troubles getting started with THE GROWTH despite statements that they did not play games on the daily basis.

Adding to the 'Getting Started' item, only few participants (#P27 and #P61; gaming and non-gaming participant respectively) have asked the researcher for help with the game, but only during the first 5-10 minutes into the game.

Difficulties of getting started as experienced by some participants might be attributed to THE GROWTH's poor tutorial design. As mentioned earlier, THE GROWTH uses a simple textual information tutorial where participants can access it at any time (albeit manually). In contrast, some well-designed games (described in the literature review chapter) have elaborated tutorial systems embedded within the gameplay – using textual, animation, and other means to guide players when they are in need and automatically (i.e. information on demand).

Time to learn to use the interface

The majority of participants (31/40) have reported that they were able to learn how to use the interface in a relative short time (rating 8-9).

The responses from 6/40 participants have indicated that they required some time to learn how to use the interface (rating 6-7). Only the responses from 3 participants have indicated moderate-major difficulties in learning how to use game interface.

Number of steps per task

The majority of participants (31/37) have perceived the number of steps per task to be just right (rating 8-9). Other 6 participants have rated otherwise, but no participant has perceived the number of steps per tasks in THE GROWTH as 'too many'.

Steps to complete a task follow a logical sequence

The majority of participants (35/41) have responded to this question very positively (rating 8-9). However, 4/41 participants have rated this item moderately (rating 6) and 2/41 participants have rated this item negatively (rating 2 and 4).

For this, responses from the majority of participants have perceived game tasks in THE GROWTH to be logically designed.

Feedback on the completion of sequence of steps

The majority of participants (35/41) have responded to this question very positively (rating 8-9). Other 4 participants have also responded to this question positively (rating 7). For this, participants' responses have indicated feedback system in THE GROWTH to be adequate.

PART 5: Interface Capabilities
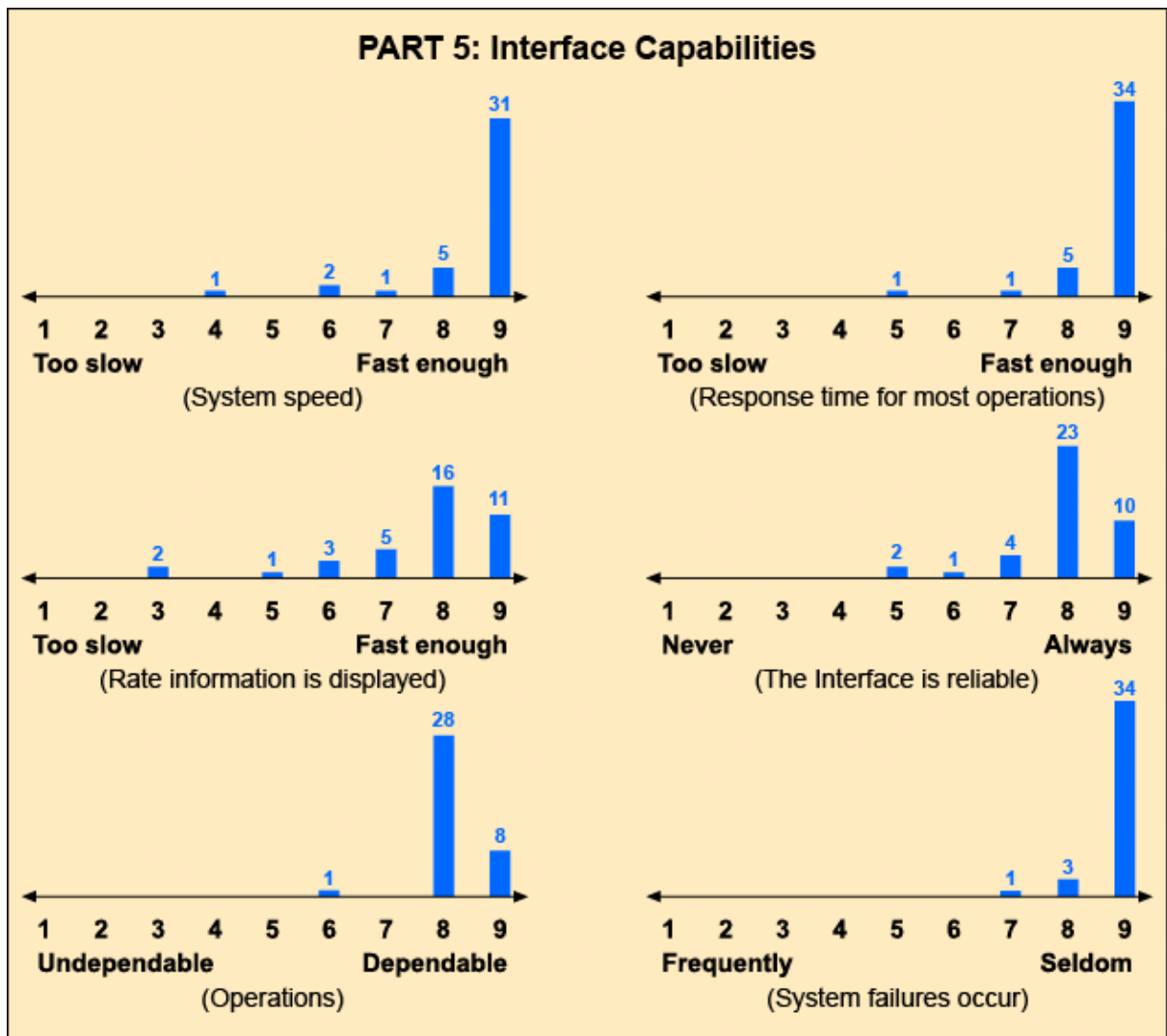
System speed

Responses from the majority of participants (36/40) have indicated that the computer power was fast enough for running THE GROWTH (rating 8-9). 3/40 participants, however, have reported slight computer performance issue and only one participant has reported major performance issue. The observation from the recorded gameplay, however, did not detect major computer performance issue for this participant.

Rate information is displayed

The majority of participants (27/38) have reported that the speed of information displayed was fast enough (rating 8-9). 8/38 participants have reported that the speed of information displayed was quite good (rating 6-7). One participant has reported moderate speed of information displayed and only 2/38 participants have reported major problems with the speed of information displayed.

The observation from the recorded gameplay, however, did not detect any major computer performance issue (that might slow down or interrupt the information display rate).

Operations

The majority of participants (36/37) have reported very positively for this question (rating 8-9).

Response time for most operation

The majority of participants (39/41) have reported that the response time for most operation was fast enough. The results were in alignment with the participants' positive responses in the 'system speed' question.

The interface is reliable

The majority of participants (33/40) have reported that the interface was very reliable (rating 8-9). 5/40 participants have reported that the interface was reliable (rating 7-8). Only 2/40 participants have reported that the interface was moderately reliable (rating 5).

System failure occur

The majority of participants (37/38) have rated the system as very reliable – in other word, minimum or no system failure occurred (rating 8-9). Another participant has rated the system as reliable (rating 6-7).

There was no case of system failure (i.e. crash) throughout the experimentation. Thus, it was assumed that 4/38 participants who have rated this question with 7-8 scores might have interpreted 'system failure' as latency and other minor technical issues (none major technical issue was detect throughout all sessions).

PART 5: Interface Capabilities (cont.)
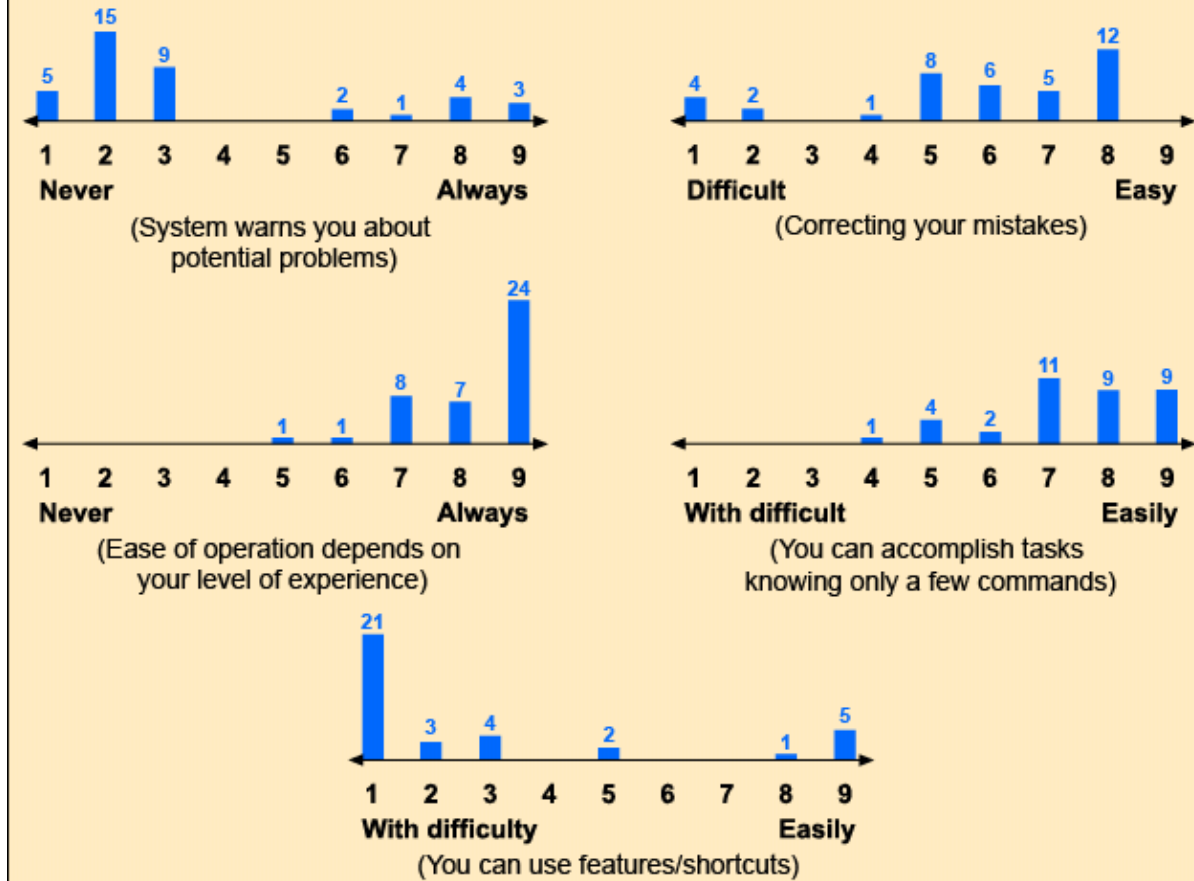
System warns you about potential problems

Only 7/39 participants have rated this question very positively (rating 8-9). 3/39 participants have also rated this question positively. On the other hand, the majority of participants (29/39) participants have rated this question negatively (rating 1, 2, 3).

The majority of participants' low ratings on this question might be attributed to the mediocre feedback system design of the current game version. The current game version uses visual feedback mechanisms such as visual effects (change of scene appearance to indicate pollution level) and pop-up GUIs (to confirm players' actions and inform players of game events). However, elaborated visual feedbacks should be considered in the next version as well as the use of sound to warn players of potential problems. As mentioned earlier, an elaborated tutorial mechanism could be embedded with the feedback system in the next version to suggest possible solutions to players when needed.

Ease of operation depends on your level of experience

The majority of participants (31/41) have rated this question very positively (rating 8-9). 9/41 participants have also rated this question positively. Only one participant have rated this questionnaire moderately (rating 5). The responses from participants have suggested that the majority of participants were able to operate the software with relative ease.

Correcting your mistakes

12/38 participants have responded to this question very positively (rating 8). 11/38 participants have also rated this question positively. 8/38 participants have rated this question moderately (rating 5). On the other hand 7/38 participants have rated this question negatively (rating 1, 2, 4).

Interestingly, the majority of participants have rated this question positively (rating 6, 7, 8) despite the fact that THE GROWTH game mechanism did not allow participants to correct their mistakes (e.g. participants cannot undo their actions in THE GROWTH).

However, participants might have interpreted the attributional feedback system of the quiz mechanism as 'mistake correction mechanism' as the system would give feedbacks to the players every time they have answered the quiz (e.g. 'correct!', 'okay!', and 'try again!').

You can accomplish tasks knowing only a few commands

The majority of participants (18/36) have responded to this question very positively (rating 8-9). 13/36 participants have also responded to this question positively (rating 6-7). On the other hand, 4/36 participants have responded to this question moderately (rating 5) and only 1/36 participant has rated this question negatively (rating 4).

The majority of participants' positive responses for this question were in line with participants' positive responses on 'tasks can be performed in a straightforward manner' question. These two questions have confirmed that the majority of participants were able to perform in-game tasks without major difficulties.

You can use features / shortcuts

The majority of participants 28/36 have responded to this question negatively (rating 1, 2, 3). 2/36 participants have responded to this question moderately (rating 5). Only 6/36 participants have responded to this question very positively.

The majority of participants' negative responses for this question can be attributed to the fact that the current version of THE GROWTH lacks keyboard shortcut function due to limited development time. The importance of shortcuts for facilitating players' software usability is highlighted in the Guideline for Environmental Game (GEG) chapter.

Several participants' moderate and positive responses on this question might be attributed to the accessibility of game 'features' via GUIs.
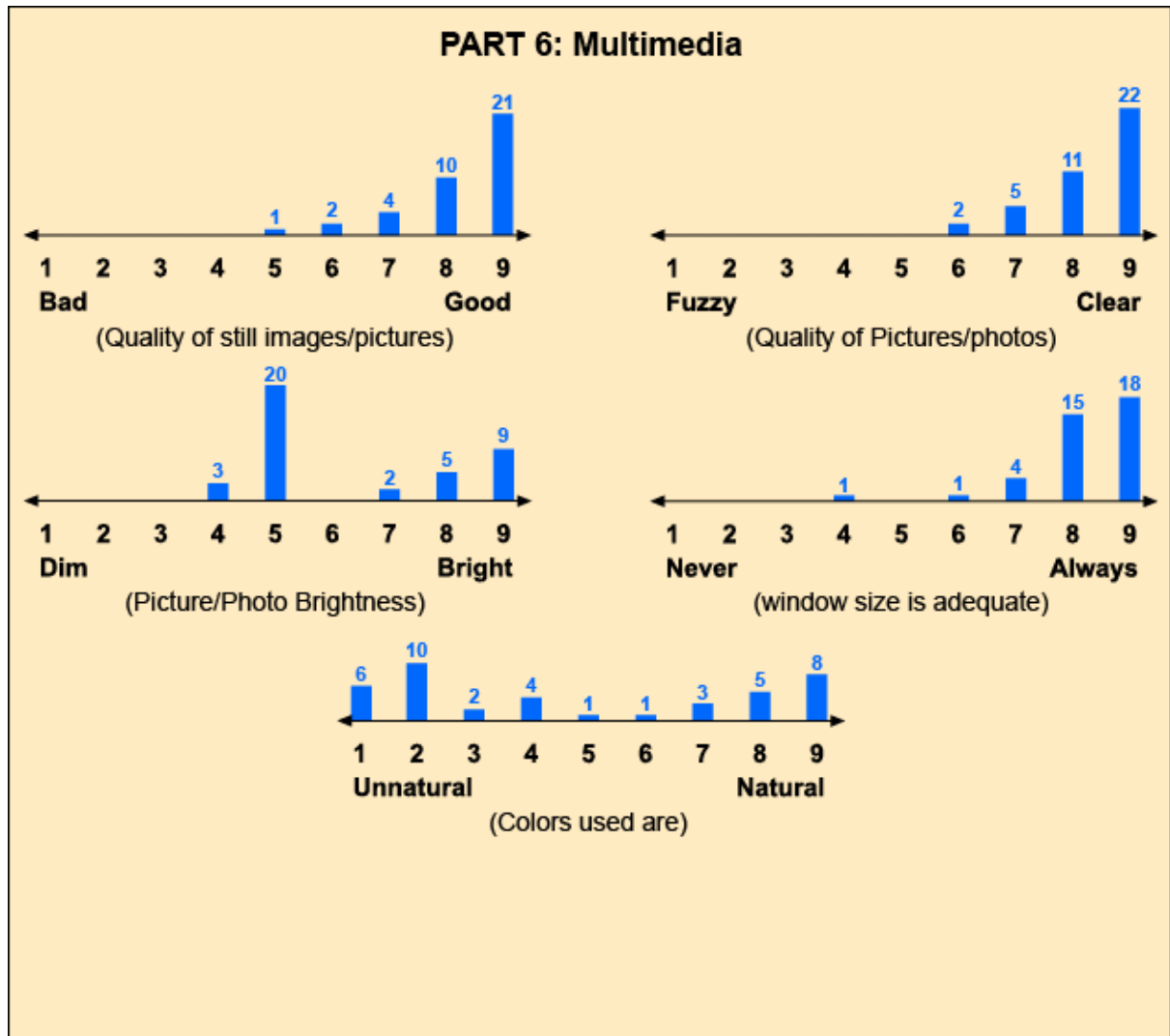
Quality of still images / pictures

The quality of still images / pictures in the game was well-received by the majority of participants. 31/38 participants have responded to this question very positively (rating 8-9) while other 6/38 participants have responded to this question positively (rating 6-7).

Picture / photo brightness

The majority of participants (20/39) have responded to this question moderately (rating 5). Other 14/39 participants have responded to this question very positively (rating 8-9).

2/39 participants have responded to this question positively (rating 7) and 3/39 participants have responded to this question negatively (rating 4).

No participant has raised a concern of screen brightness during game sessions. Further, the observations from recorded gameplays have indicated that the brightness of the computer screen was at the optimal level for all sessions (both indoor and outdoor settings).

Thus, a possible explanation of results for this question is that 20/39 participants might have interpreted the 5th score in the middle of the scale as 'optimum' whereas the 9th score might have been interpreted as 'too bright '. On the other hand, 14/39 participants might have interpreted the 8th and 9th score of brightness as 'optimum'.

Quality of pictures / photos

The majority of participants (33/40) have responded to this question very positively (rating 8-9). Other 7/40 participants have also responded to this question positively (rating 6-7). Positive responses from participants have indicated that display resolution for the game was at acceptable level.

In each experimental session, the game was set to run at 1440×900 resolution and the performance set to maximum quality. However, all static pre-rendered images in the game were presented at 800×600 resolution due to hardware limitation during the development stage. Using development-grade computer system, the quality of static images could be improved significantly in the next version by pre-rendered them at higher resolution.

Window size is adequate

The majority of participants (33/39) have responded to this question very positively (rating 8-9). 5/39 participants have responded to this question positively (rating 6-7). Only 1 participant has responded to this question negatively.

Responses from participants have indicated that the use of 14-inch monitor appeared to be adequate for running the game.

Colors used are … (unnatural / natural)

The majority of participants (22/40) participants have responded that the color used was 'unnatural' (rating 1, 2, 3, 4).

On the other hand, 13/40 participants have responded that the color used was 'natural' (rating 8-9). 4/40 participants have responded that the color used was 'quite natural' (rating 6-7). Only 1 participant has responded that the color used was neither natural nor unnatural (rating 5).

The dispersed responses from participants to this question might be attributed to participants' different interpretation of the question. THE GROWTH's storyline was set in a dystopian world with high-level of environmental contamination. Thus, many game objects such as buildings and landscapes were stained by 'unnatural' pollutants.

To this end, participants who responded with 'natural' might have interpreted this as 'aligning with the game concept of a dystopian world'.

2. Reader satisfaction: Control group

A set of reader satisfaction questionnaire was developed from the QUIS questionnaire discussed above. The aim of the reader satisfaction questionnaire was to understand participants' reception on the reading material.
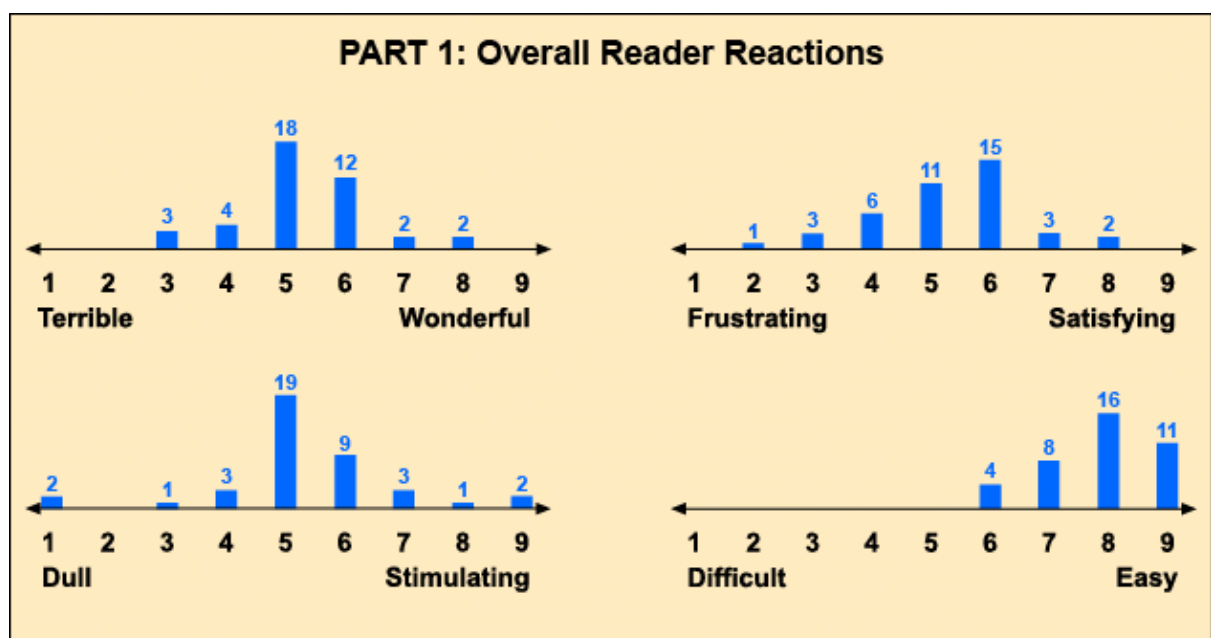
Overall reader reactions: Terrible-Wonderful

The majority of participants have casted their scores to this questionnaire part moderately. For 'Terrible-Wonderful' part, 18/41 participants have responded to this question moderately (rating 5) while 7/41 participants have responded to this question negatively (rating 3-4).

14/41 participants have responded to this question positively (rating 6-7). However, it should be noted that 12/14 participants have casted their scores into the lower bound area (rating 6) which can be considered as 'medium-positive' rather than 'positive' responses.

Only 2/41 participants have responded to this question very positively (rating 8).

Overall reader reactions: Dull-Stimulating

Similarly, the majority of participants (19/40) have responded to this question moderately (rating 5) while 6/40 participants have responded to this question negatively (rating 1, 3, 4). On the other hand, 12/40 participants have responded to this question positively (rating 6-7) and only 3/40 participants have responded to this question very positively (rating 8-9).

Overall reader reactions: Frustrating-Satisfying

The majority of participants (18/41) have responded to this question positively (rating 6-7). However, it is worth to note that 15/18 participants have casted their scores into the lower bound area (rating 6) which can be considered as 'medium-positive' rather than 'positive' responses.

10/41 participants have responded to this question negatively (rating 2, 3, 4). Only 2/41 participants have responded to this question very positively.

Overall reader reactions: Difficult-Easy

The majority of participants (27/39) have responded to this question very positively (rating 8-9) – indicating that the majority of participants considered the reading material as 'easy to read'. On the other hand 12/39 participants have responded to this question positively (rating 6-7).

PART 2: Readability

Characters in the reading material

The majority of participants (38/40) have responded to this question very positively (rating 8-9) – indicating that participants were able to read characters in the reading material easily. 1/40 participant has also responded to this question positively (rating 7). Only 1/40 participant has responded to this question moderately.

Character shapes (fonts)

The majority of participants (39/40) have responded to this question very positively (rating 8-9) while other 1/40 participant has also responded to this question positively (rating 7) – indicating that Arial, as the main font shape, was considered by participants as very legible.

Image of characters

The majority of participants (37/39) have responded to this question very positively (rating 8-9). Other 2/39 participants have also responded to this question positively (rating 7) – indicating that the print quality was adequate for participants' reading comfort.

Reading material layouts were helpful

The majority of participants (20/40) have responded to this question positively (rating 6-7). 16/40 participants have also responded to this question very positively (rating 8-9) – indicating that the majority of participants have considered the layout of the reading material to be helpful.
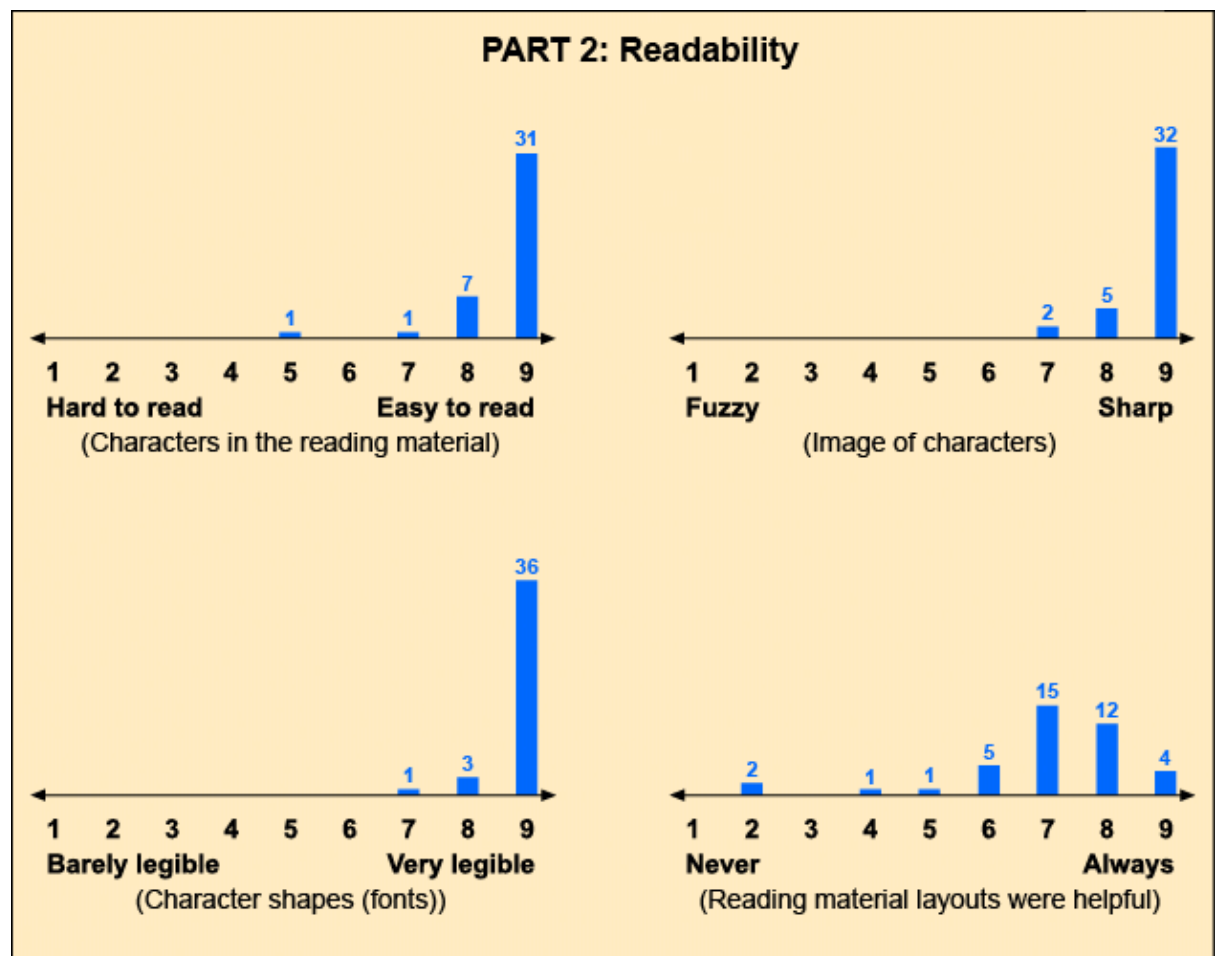
On the other hand, 1/40 participant has responded to this question moderately (rating 5) while other 3/40 participants have responded to this question negatively (rating 2, 4).

Amount of information that can be displayed on the reading material

The majority of participants (30/40) have responded to this question very positively (rating 8-9). Other 7/40 participants have also responded to this question positively (rating 6-7) – indicating that the majority of participants have considered the amount of information displayed on the reading material to be adequate.

On the other hand, 2/40 participants have responded to this question moderately (rating 5) while only 1/40 participant has responded to this question negatively (rating 4).

Arrangement of information displayed on each page

The majority of participants (19/40) have responded to this question very positively (rating 8-9). Other 16/40 participants have also responded to this question positively (rating 6-7) – indicating that the majority of participants have considered the arrangement of information to be logical.

On the other hand 3/40 participants have responded to this question negatively (rating 2, 4) while 2/40 participants have responded to this question moderately.

PART 3: Learning to use the reading material
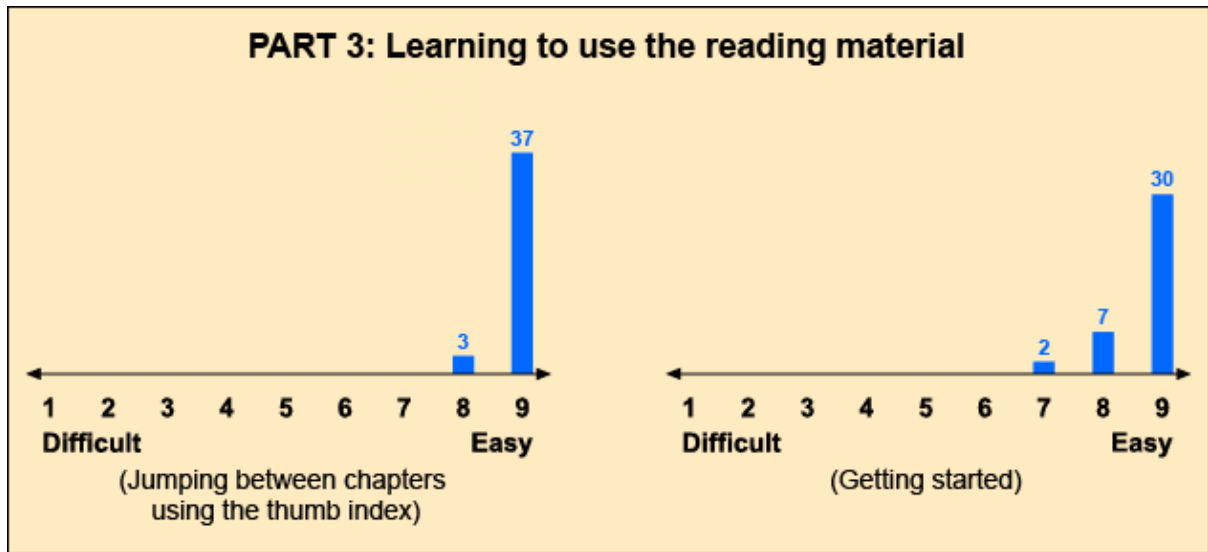
Jumping between chapters using the thumb index

As mentioned earlier, the thumb index (small pieces of paper hanged from pages) was used to separate one chapter from others. It was also included to enable and encourage participants to switch from one chapter to another with ease

All 40/40 participants have responded to this question very positively (rating 8-9) – indicating that the majority of participants have considered the use of thumb index provided in the reading material to be easy.

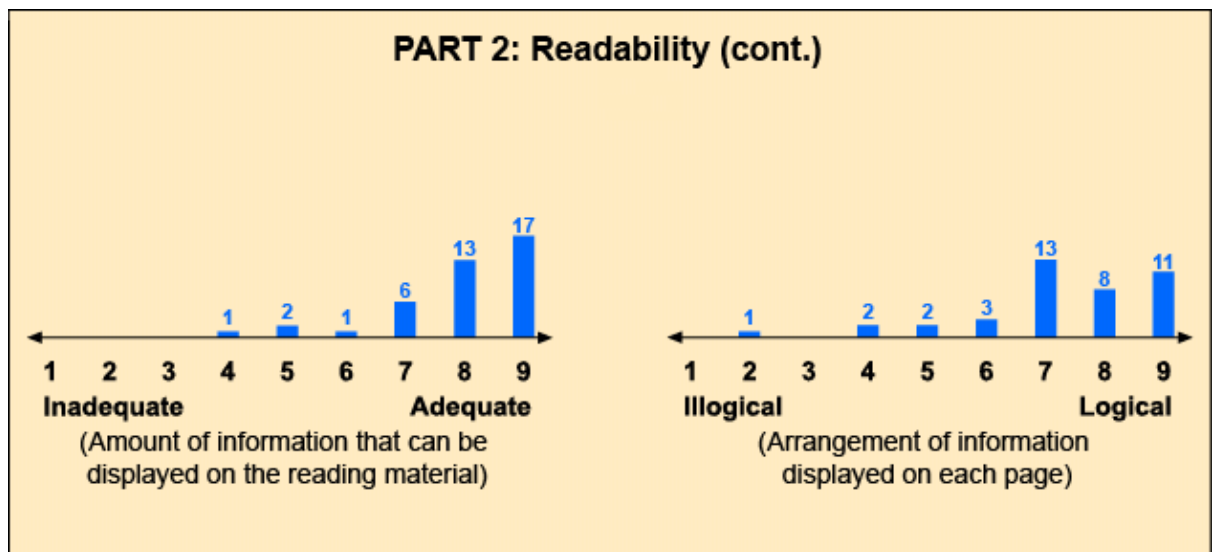**Getting started**

The majority of participants (37/39) have responded to this question very positively (rating 8-9) while other 2/39 participants have responded to this question positively – indicating that the majority of participants considered getting started with the reading activity in the reading material to be easy.

3. Comparisons between the experimental and the control group

Overall user reactions: Terrible-Wonderful

In this part, 16/41 participants from the experimental group (39.02%) have considered the game to be wonderful (rating 8-9) while other 19/41 participants (46.34%) have also considered the game to be quite wonderful (rating 6-7) – indicating that the majority of participants from the experimental group perceived their session to be enjoyable / stimulating.

In contrast, the majority of participants from the control group (16/41; 39.02%) have considered the reading material to be neither terrible nor wonderful (rating 5). Other 14/41 (34.15%) have considered the reading material to be 'okay' (rating 6) – indicating that the majority of participants from the control group did not enjoy the experimental session as much as the majority of participants from the experimental group.

Overall user reactions: Dull-Stimulating

The majority of participants from the experimental group (19/41; 46.34%) have considered the game to be quite stimulating (rating 6-7) while 13/41 participants (31.71%) have considered the game to be stimulating (rating 8-9).

On the other hand, the majority of participants from the control group (19/40; 47.50%) have considered the reading material to be neither dull nor stimulating (rating 5) while 12/40 participants (30%) have considered the reading material to be quite stimulating (rating 6-7). However, it should be noted that 9/12 participants have casted their scores into the lower bound area (rating 6) which can be considered as 'medium-positive' rather than 'positive' responses.

Thus, the comparison between treatment groups has indicated that the majority of participants from the experimental group have considered the game to be quite stimulating while the majority of participants from the control group have considered the reading material to be neither dull nor stimulating.

Overall user reactions: Frustrating-Satisfying

The majority of participants from the experimental group (24/39; 61.54%) have considered the game to be quite satisfying (rating 6-7) while other 13/39 (33.33%) have considered the game to be satisfying (rating 8-9).

On the other hand, the majority of participants from the control group (18/41; 43.90%) have considered the reading material to be quite satisfying (rating 6-7). However, it should be noted that 15/18 participants have casted their scores into the lower bound area (rating 6) which can be considered as 'medium-positive' rather than 'positive' responses. Other 11/41 (26.83%) have considered the reading material to be neither frustrating nor satisfying (rating 5).

Also, 10/41 participants (24.39%) from the control group have considered the reading material to be quite frustrating (rating 2, 3, 4) compared to only 1/39 participant from the experimental group (2.39%) who considered the game to be quite frustrating (rating 3).

Thus, the comparison has indicated that the majority of participants from the experimental group have received higher level of satisfaction compared to the majority of participants from the control group.

Overall user reactions: Difficult-Easy

The majority of participants from the experimental group (13/41; 31.71%) have considered the game to be quite easy (rating 6, 7). Other 12/41 participants or 29.27% have considered the game to be easy (rating 8-9) while 11/41 participants have considered the game to be neither easy nor difficult (rating 5). Only 5/41 participants (12.20%) have considered the game to be difficult (rating 2; N=2) and quite difficult (rating 4; N=3)

On the other hand, the majority of participants from the control group (27/39; 69.23%) have considered the reading material to be easy (rating 8-9) and other 12/39 participants or 30.77% have considered the reading material to be quite easy (rating 6-7).

Thus, the comparison has indicated that a number of participants from the experimental group have experienced higher level of difficulties compared to participants from the control group. The result, however, was predictable as participants from the experimental group were put into a 'more active role ' (e.g. strategic planning & managing multiple game factors) while participants from the control group were simply read the information from the reading material.

However, as indicated by the learning outcome results, the perceived level of difficulty in the game did not appear to impede participants' learning process. The challenging and complex learning approach provided by the game was noted by some researchers such as Gee (2005) and Squire (2011).

Reading from the computer screen VS reading from the paper-based reading material

Hard / Easy to read

The majority of participants from the experimental group (33/41; 80.49%) have considered reading from the computer screen to be easy (rating 8-9). 7/41 participants (17.07%) have also considered reading from the computer screen to be quite easy (rating 6-7). Only 1/41 participant has considered reading from the computer screen to be neither hard nor easy (rating 5).

On the other hand, the overwhelming majority of participants from the control group (37/39; 94.87%) have considered reading from the reading material to be easy (rating 8-9) and other 2/39 participants have considered reading from the reading material to be quite easy (rating 7).

The comparison has indicated that participants from the control group have considered reading from the reading material to be easier when compared to participants from the experimental group considered reading from the computer screen. This result was predictable as individuals' preferences on reading from paper-based material over computer screen have been noted in many real-world settings.

As indicated by participants' responses, the majority of participants from the experimental group did not experience major difficulties in reading from the computer screen. Only a small number of participants from the experimental group (4/41; 9.76%) have reported some difficulties in reading from the computer screen (rating 5, 6).

Character shape (fonts)

39/39 participants from the experimental group have considered the font shape to be very legible (rating 8-9).

Similarly, 39/40 participants from the control group have considered font shape to be very legible (rating 8-9) – indicating that 'Arial', as the main font shape was considered as very legible by the majority of participants from both treatment groups.

Image of characters

35/41 participants from the experimental group (85.37%) have considered characters' image to be sharp (rating 8-9) while 5/41 participants (12.20%) have also considered characters' image to be quite sharp (rating 6-7).

On the other hand, 37/39 participants from the control group (94.87%) have considered characters' image to be sharp (rating 8-9) while 2/39 participants have also considered characters' image to be quite sharp (rating 7) – indicating that there was no significant difference in opinions on the characters' image between both treatment groups.

Layouts

The majority of participants from the experimental group (36/41; 87.80%) have considered the layouts in the computer screen to be helpful (rating 8-9). 4/41 participants (9.76%) have considered the layouts in the computer screen to be quite helpful (rating 6-7).

On the other hand, the responses have been more diverse for participants in the control group where the majority of participants (20/40; 50%) have considered the layouts in the reading material to be quite helpful (rating 6-7). 16/40 participants (40%) have considered the layouts in the reading material to be helpful. 3/40 participants (7.50%) have considered the layouts to be not

quite helpful (rating 2, 4) and only 1/40 participant has considered the layouts to be neither unhelpful nor helpful.

As mentioned earlier, there were some dissimilarity in layouts between the game and the reading material version – specifically in chapter 1 and 2 of the reading material that tried to imitate 'the quiz' and 'the storyline' aspect of the game version.

Further, the game version allows participants to view the textual and graphical information selectively while the reading material version simply 'throw' all the information to players at once. Thus, the more positive responses from the experimental group participants on the layouts might be attributed to what Gee (2003) has described the as 'information on demands' (see GEG chapter).

The amount of information displayed on the computer screen / reading material

The overwhelming majority of participants from the experimental group (36/38; 94.74%) have considered the amount of information displayed on the computer screen to be adequate (rating 8-9).

On the other hand, the majority of participants from the control group (30/40; 75%) have considered the amount of information displayed on the reading material to be adequate (rating 8-9). 6/40 participants (15%) have considered the amount of information displayed on the reading material to be somewhat adequate.

Although participants from the experimental group have rated this question more positively when compared to participants from the control group, there was no significant difference between both treatment groups.

Arrangement of information displayed on the screen / on each page

The majority of participants from the experimental group (37/41; 90.24%) have considered the arrangement of information on the computer screen to be logical (rating 8-9). 3/41 participants have considered the arrangement of information on the computer screen to be somewhat logical (rating 7) and only 1/41 have considered the arrangement of information on the computer screen to be neither logical or illogical (rating 5).

On the other hand, the majority of participants from the control group (19/40; 47.50%) have considered the arrangement of information on the reading material to be logical (rating 8-9). 16/40 participants (40%) have considered the arrangement of information on the reading material to be somewhat logical (rating 6-7). 2/40 participants have considered the arrangement of

information on the reading material to be neither logical nor illogical while other 3/40 participants have rated this question negatively (rating 2, 4).

Although the arrangement of information in the game and the reading material was quite similar to each other, the comparison has indicated that the majority of participants from the experimental group (game group) have higher opinions regarding of information arrangement in the game than that of the control group participants to the reading material. Again, the advantage of information arrangement in the game over the traditional learning material might lie in what Gee (2003) has described the as 'information on demands'.

Getting started

The majority of participants from the experimental group (18/41; 43.90%) have considered getting started with the game to be quite easy (rating 6-7) while other 16/41 participants (39.02%) have considered getting started to be easy (rating 8-9). 5/41 participants have considered getting started to be neither difficult nor easy and only 2/41 participants have indicated that they had encountered difficulties in getting started with the game (rating 2, 4).

On the other hand, the overwhelming majority of participants from the control group (37/39; 94.87%) have considered getting started with the reading activity to be easy (rating 8-9) while other 2/39 participants have also considered getting started to be quite easy (rating 7).

Predictably, getting started appeared to be more difficult for participants using the game (the experimental group) when compared to the participants using the reading material (the control group) due to the fact that participants from the game group have to learn and familiarize themselves with game factors. However, difficulties in getting started for the game group did not appear to deter participants from completing the task nor impede the learning outcome (as suggested by the learning score outcomes in the main analysis).

4. Supplemental survey questions

4.1 Self-reported learning evaluation: On the scale of 1-10, could you please rate how much you've learned from the game / reading material?

Overall, there was no significant difference in self-reported learning evaluation scores between the experimental and the control group although participants from the experimental group appeared to rate this question slightly higher when compared to participants from the control group (Total score = 289 VS 256).

On the scale of 1-10, how much you've learned from the game?					
Study group	Mean	Median	Mode	SD	VAR
Experimental (N=37)	7.05	7	7	1.40	1.95
Control (N=39)	6.24	6	7	1.14	1.29

For a number of participants, however, it appeared that there was no correlation between knowledge gained (post-test / improvement scores) and self-reported learning evaluation.

To this, a number of participants have rated the self-reported learning evaluation highly despite their relatively low knowledge score outcomes (lower than 12 score or > 50% out of 23 test questions). On the other hand, few participants have rated the self-reported learning evaluation lowly despite their relatively high knowledge score outcomes.

6 of such instants have been detected in responses from participants of the experimental group and 18 have been detected in responses from participants of the control group.

One possible explanation may lie in misconception where participants perceived that they have gained high knowledge outcome despite the relatively low knowledge results / scores (the pre- and post-test results were not revealed to participants).

Another possible explanation may lie in the fact that a number of content in the game / reading material were not included into the knowledge assessment questionnaires (pre- and post-test) as they were deemed excessive. Examples of these contents include: collection of reports on recent technological developments and strategies for environmental conservation. Thus, participants may have obtained the knowledge, albeit untested by the assessment questionnaire.

This second possible explanation is supported by a number of topics recalled and discussed by participants from both the experimental and the control group (see interview section).

4.2 Comments about the game

Few participants have made comments about the game. It appeared that the commenters are mainly concerned with the visual aspect of the game (e.g. artwork enhancement, improved animation, and the expansion of visual content).

A participant has suggested that the animation in the game should be expanded. The participant also suggested the use of camera panning to help visualize the landscape of the game.

- #P1-EXP – *"I'm enjoyed [the game] and learn quite a lot of new stuff from it. The artwork is gloomy but also impressive. <[]> I think there should be more animated objects in the game. It feels a little bit static. Also, it would be nice to be able to pan the camera around ... kind of make it like you are really in the city. <[]> Like when you play strategy games".*

Another participant has suggested the enhancement of micro-management system of the game.

- #P3-EXP – *"I think the concept of harvesting of forest product could take a further step by allowing certain products to be harvested. For example, you could have a sub-menu where people are allowed to harvest wild honey but not animal carcass. This is because the harvest of wild honey will be far less damaging to the environment than allowing the trade of animal carcass. You could say [the harvest of wild honey] will make less money than trading deer' antlers and whatever ... kind of give players more control and let them judge between money and the environment".*

Another participant has suggested for content expansion. It appeared that the participant has a negative opinion regarding of using the quiz mechanism in the game – citing the breaking of immersion as the reason. The participant also suggested about visual enhancement of the game.

- #P81-EXP – *"I think the game has shown interesting things about problems in the world. It's kind of confusing at the start because there are so many things to do, but it's not too hard once you've learned to play the game. There are also many upgrades in the game and I would like to see more of that.*

... It's kind of strange the way the game using quiz. It feels like the game you might use to teach children in the classroom. I don't know ... it's not that bad though. It's just unlike other games ... kind of taking away the immersion.

I also think the animation and lighting should be improved in the game scene. The game scene kind of look different from [static images in the game] though. <[]> the visual quality of the static images are much better than the ones in the game scene".

Another participant has suggested the expansion of the visual content. The shifting from 3D to 2D environment was suggested by the participant as an alternative game design.

The participant has also suggested including interactivity with objects in the game scene (currently objects representing buildings in the game scene serve no purpose apart from indicating pollution level in the region). Indeed, the planned interactivity with objects in the game scene was omitted from the development due to time restriction.

- #P41-EXP – *"I think the game scenes should be expanded. <[]> I like the detailed level of buildings [in the game] … they look interesting … different from our world, yet some of them look similar to our world. <[]> Somehow I think the [static images] and the image at the main menu look a lot more interesting than the 3D objects [in the game scene]. As I said, I wouldn't mind if whether it is 2D or 3D as long as it looks good.*

<[]> Also it would be better to have buildings in the game scene serve some purposes. Perhaps the players should be able to upgrade buildings in the game scene by selecting them directly?"

Another participant has suggested the overhaul of the artwork design. The participant's suggestion could also be partially linked to the 'gender stereotype' effect where the players have perceived that the game was not design for their gender.

- #P44-EXP – *"There are some games or cartoons out there which can be creepy and cute at the same time <[]> … like, the cartoon CORPSE BRIDE. It's kind of creepy, but not too strong … not too realistic like [THE GROWTH]. I think [THE GROWTH] would be attractive to male players. I would prefer something a little more cartoonish".*

Appendix 09: The list of items recalled from the learning mediums

The following is the list of items recalled by participants from their respective learning mediums (THE GROWTH / the reading material). In order to minimize risks of knowledge contamination, participants were asked to recall the items at once. Subsequent recalled items were not included into this list.

Table: The frequency distribution of environmental, societal, and technological issues recalled by the participants

Issues recalled	Experimental Group (N=29)	Control Group (N=32)	Total
Crimes	23	26	49
Forest conservation	23	20	43
Smart products	28	13	41
Pollution (air / water / soil)	15	18	33
Solar technology	17	15	32
Robotic & Automation technology	14	14	28
Unplanned pregnancy	13	11	24
Public transportation & Carpool	11	8	19
Recycle	6	10	16
Garbage	7	7	14
Growing population	11	3	14
Food safety	5	7	12
Water conservation	7	5	12
Energy conservation	7	3	10
War	4	6	10
Sustainable farming	6	3	9
Wildlife conservation	4	5	9
Food processing & preservation technology	3	5	8
Poverty	4	4	8
Radiation	2	6	8
Accidents	4	3	7
Bio-technology	3	4	7
Diseases	5	2	7
Marine conservation	5	2	7
Wind turbine	6	1	7
Anaerobic digester	3	3	6
Condom	5	1	6
Managed hunting	2	4	6
Energy storage	3	2	5
Debts	3	2	5
Sustainable harvest of forest products	4	1	5
Durable products	3	1	4
Starvation	3	1	4
Draught	2	1	3
Eco-diner	1	2	3
Invasive species	2	1	3
Organic foods	2	1	3

Plastic reduction	1	2	3
Prison farm	1	2	3
Wave energy	2	1	3
Eco-fashion	0	2	2
Eco-tourism	1	1	2
Global warming	0	2	2
Pet management	1	1	2
Carbon tax	0	1	1
Disaster	0	1	1
Environmental informant	0	1	1
Flood	1	0	1
Total	273	235	508

Appendix 10: Interview statements

This section contains the full interview statements obtained from the participants. Participants' viewpoints on the environmental, social, and technological issues are linked to Centre for Alternative Technology (2010)'s behavioral pattern where possible.

1. The ultimate question: "Would you agree with the concept of pollution tax?"

1.1 Disagreed with the pollution tax policy

A participant, while expressed his appreciation with human-nature coexistence, has disagreed with the concept of pollution tax. The participant has cited the dilemma of choices, city workers' contribution to the economy, enhanced healthcare, and security system provided by modern technology.

In what can be linked to the 'scapegoating effect' (Centre for Alternative Technology 2010: 155), the participant also reasoned that the populace in the provincial areas (who appeared to live a more sustainable lifestyle than the urban populace) are also indirectly responsible for the pollution problem by receiving supports from the urban populace. The participant has also recognized 'work & spend' lifestyle as a barrier for pro-environmental actions / behaviors.

- #P1-EXP – *"I think it depends on lifestyles. I think people in provincial areas would prefer simple lifestyles ... living in harmony with nature. They don't seem to be in hurry ... just work in fruit orchards all day and go fishing after. Most of people from the provincial areas I've met are pretty relaxed.*

  On the other hand, those who work in city areas are always in hurry. Of course, we use cars, energy and create more pollution problem more than [those who live in provincial areas]. But we also work hard and contributed more tax revenue for the country than them.

  The government also uses tax money to help them when they cannot make enough money from selling agricultural products. So by accepting the financial aids and depending on business for the exports, those who live in provincial areas also contributed to pollution problems as well. This is how the world works. We have access to medical care and security system is much better in major cities when compared to provincial areas.

  <[]> I think it depends on people lifestyles and thus, very hard to change. People work hard to get wealthy and the point of being wealthy is to spend the money on products ... or travel aboard".

Similarly, another participant has reasoned that the price increase might affect consumers' purchasing behaviors (by referring to his personal experience abroad). In disagreement with the pollution tax policy, the participant has noted the pollution tax's negative effect on the poor, the possibility of social disturbances, and the political challenges from introducing the policy.

- #P8-CTRL – *"... However, I can see that it might help control people on their spending. Like, not to waste energy unnecessary <[]> I think prices play the key role in regulating people's consumption lifestyles. <[]> People will plan their spending carefully when faced with financial difficulty. I used to study in the United Kingdom where electricity, food, and everything else were significantly much more expensive than in Thailand <[]> and I was forced to control my spending.*

  However, the government must be careful rigging the price because the poor are likely to be affected by the raised living cost. If the poor cannot earn enough to feed their families then they might resort to crimes and other illegal activities and that would be bad for the society as a whole. Besides, the government will lose its popularity with this policy".

A participant has disagreed with the concept of pollution tax, while also cited the aspect of choices (welfare). Interestingly, the participant has seemingly discussed about the possibility of using involuntary population control as the mean to decrease resources consumption.

- #P31-CTRL – *"I think it depends on what people valued most. Electronic devices are bad for the environment, but still the elder and people with disability depend on it. I know an old lady whose life is depended on the life support system round the clock. There's even couple of back-up batteries in case of power failure. Now if 10,000 people need a similar device then the manufacturer will need to make more of these devices which would be bad for the environment ... and how about 1 million people? So I think people have to decide whether they want to live longer and well or decide to live uncomfortably for the sake of the environment.*

  <[]> I'd choose to live longer. Well, I think most people will choose to live longer too. So it would be more reasonable that we decrease population size to make resources affordable for everyone. However, I don't think people are going to cooperate with this so maybe the government should limit each family to two children ... this is depended on the situation, of course".

Another participant has disagreed with the pollution tax policy. In her account, the participant has expressed a concern over governmental transparency which can be linked to the 'distrust' effect as highlighted by Centre for Alternative Technology (2010: 152).

The participant's account has also highlighted the dependent on new technologies (i.e. tech-fix). Similar to #P27-EXP, the dilemma of choices such as the comfort of modern lifestyles and welfare issues that must be sacrificed for the betterment of the natural environment was highlighted in her account.

Interestingly, the concept of population reduction was highlighted by the participant as the possible solution. Also, the participant has suggested for pollution tax to be postponed and then followed by a gradual price increase (possibly in order to allow the public sometimes to adjust to the change). Yet, still, the participant has suggested that the tax for vital products such as foods should be considered carefully to prevent social disturbances.

- #P44-EXP – "[Pollution tax policy] doesn't sound right to me. What if the government has increased price for products only to realize sometime later that they have overestimated the price? Will I get my money back? I don't think so. We … as human being should be able to enjoy some luxuries in our lives. If the entire world had agreed that we're having serious environmental problems then world leaders should combine their efforts and do something in order to solve environmental problems.

  <[]> For example, instead of wasting our tax money [the governments] could fund the scientists to develop new technologies that would solve [environmental] problems. If the world population is the problem then they should promote one-child policy or … abortion so [rapid resources consumption] and pollution problems can be slowed down.

  <[]> For me, every human living on this planet should be able to enjoy products and services as permitted by his / her financial situation. If everyone goes to work in the morning without having a shower then I can see that the water can be conserved and the pollution can be prevented, but at what cost? Everyone would smell horrible and people would be more likely to develop skin diseases.

  Many lives could be saved because we have communication technologies like computers and the internet. Of course computers are bad for the environment, but the question is what is the most important? Is it the beauty of natural environment or lives and welfare of humans on the planet?

  If the [pollution tax policy] is the only way out then they should halt it for another 10 years then slowly increase the price. They could start with luxurious products such as cars, and household chemical products. Agricultural products should be exempted from the tax during

the first phase because everyone depends on them and the sudden tax could cause social disturbances".

Another participant has disagreed with the concept of pollution tax policy and suggested that the idea should be put on hold. This can be linked to the belief that environmental issue is a 'distant problem' as highlighted by Centre for Alternative Technology (2010: 153). Also, the participant's suggestion to wait for actions from other developed nations can be linked to 'others should lead' stance as highlighted by Centre for Alternative Technology (2010: 155).

- #P22-EXP – *"I think the government should wait to see if things are really that bad. At least have a look at other developed countries if any of them are consider anything like that. Yes, we have pollution and environmental problems, but maybe it's still not necessary at this time. Maybe the scientists should come up with the estimation. Like, we might consider using the pollution tax when the situation is reaching 'quite bad' status".*

Similarly, another participant has disagreed with the concept of pollution tax policy (citing financial difficulty) and suggested social issue as an issue with higher priority. The participant has reasoned that the orderly society will also bring about environmental improvements (possibly through empowered law enforcement). However, the participant's statement can also be linked to 'other things are more important' attitude as highlighted by Centre for Alternative Technology (2010: 158).

- #P67-CTRL – *"It's so hard to live these days and this will make things a lot harder. <[]> The country has more problematic social issues to deal with. Let us focus on important things like dealing with crimes and corrupted officials first. The environmental problem will disappear when the society is in good order anyway".*

1.2 Agreed & partially agreed with the pollution tax policy

A participant has expressed her support toward the concept of pollution tax by recognizing the benefit on the natural environment. The participant has also suggested an adjustment for the concept of pollution tax.

By describing about pollution transfer between countries and developed countries' imports of unsustainable products from developing countries, the participant has shown her awareness about pollution issues. However, the participant's suggestion on making pollution tax as a global policy could be linked to the 'free riders effect' where people have refused or reluctant to perform environmentally because of the perceived lack of actions by others (Centre for Alternative Technology 2010: 156).

- #P27-EXP – *"I agree with [the pollution tax policy] and I think it will benefit the environment. However, I think the tax should be devised wisely ... take cars for example, people should not be taxed for owning a car. Instead, they should be taxed according to driving mileage and performance of car engines".*

  It is important that global nations must reach a mutual agreement on the policy too. Say, what if neighboring countries have refused to adopt a similar policy and the pollution fallout from their countries have spread into our territory? Also, I've heard that developed countries are using developing countries to make products for them to avoid polluting their lands and harming their people".

On the other hand, a participant simply agreed with the pollution tax policy. From the participant's statement, it is plausible to assume that his agreement with the pollution tax policy is a product of his modest lifestyle. The participant also suggested for elimination of corruption to gain access to financial resources.

- #P43-CTRL – *"I'm okay with it <[]> Well, it is going to make the world better. I'm not going to waste the money on unnecessary products anyway ... however, I feel that if we can stop the corruption then we will have a huge amount of money for environmental protection and much more".*

Similarly, another participant has recognized both the environmental and health benefits from the pollution tax policy, but also raised a concern about corruption and transparency issues.

- #P81-EXP – *"I would pay more if the [pollution tax] can really be used to improve the environment. <[]> But it is important to ensure that powerful businesses and industries will pay their shares too. <[]> I mean the policy must be transparent and applied to everyone equally. <[]> As a parent, I would want my kids to breathe and eat without fear of pollution contamination and I'm sure that other parents would want that too".*

Another participant has agreed with the concept of pollution tax based on the benefits of the natural environmental. Similar to #P8-CTRL, the participant was aware of the tax's effects on livelihood of the population. The participant has also referred to the in-game description of 'Carbon Tax' (similar to the concept of pollution tax).

- #P30-EXP – *"I think the pollution tax should be used to conserve the natural environment. <[]> It maybe because I live a simple lifestyle so I agree with the policy, but I don't think people should consider the tax as government's effort to limit their spending and control their lives.*

<[]> I understand that the policy would affect the livelihoods and lifestyles of many people including myself. However, I think it is a necessary to ensure the future of our planet. Like many new policies, I can imagine that a lot of people will protest against the idea and there will be resistance in a similar way to the game, but I think our children and grandchildren will become accustomed to the policy one day".

2. Top 5 environmental topics

2.1 Forest Conservation

- #P2-CTRL – *"I think the forest is very important considering [the reading material] said that forest areas are diminishing in Thailand. All of us have been told that forest can reduce severity of flood. There are beautiful animals in the forest so it would be sad if we cut the trees and destroy their homes".*

- #P5-EXP – *"It is important to protect the forests because, otherwise, there won't be anything left in the future. However, it's hard because people only care about themselves. At this rate, it's only the matter of time but maybe I won't live long enough to see that.*

  <[]> I think it's important for the government to invest the budget into environmental protection projects. Consider that our country is based on agriculture economy, destroying the environment will cause negative impacts on the economy as well.

  At the same time, schools should spend more time taking children to learn outside the classroom … to see the real world. There's no point in training children to be smart scientists if they don't care about the country. Instead, if we introduce the king's teaching of living sustainably to the school then more children will become good persons in the future. I believe a number of pollution problems will be reduced even if half of Thai citizens decide to [live sustainably]".

- #P17-CTRL – *"I think it depends on lifestyles. <[]> I think it's where you live. For example, you have to look neat if you want to live in Bangkok or otherwise people will look down on you. The culture of office workers in Bangkok encourages you to show off your wealth … cars, expensive watches, shirts, handbags, shoes and whatnot.*

  It's very sad because I've seen people being shunned by their colleagues simply because s/he doesn't wear 'classy' items. I think it's a very pathetic culture that people are judging others by their 'outer shells'.

<[]> We only need to change this cultural value and things will be better. Look at people in provincial areas … they are smart, wealthy, and moral. However, they have no need to show off their wealth. They wear plain clothes and live a simple life. I wear a pair of old jeans that my mother has fixed for me and no one in the [provincial] areas would look down on me. However, you cannot blame all this on people because they are being brainwashed by the media like soap operas, newspaper, and advertisement".

- #P19-EXP – *"Natural habitat and natural resources are vital for all life-form. We've been told all the time since we were children to conserve the resources and use them wisely. However, the reality is totally different from what we've been told when we were children. People are concerned with their own business and can't be bothered to think about others or the world.*

  <[]> People want to get rich, but forgot that wealth is not everything in their lives … they live short and die fast without understanding the meaning of life … the happiness of helping others and appreciate the nature … Well, not everyone is that bad but many people I've encountered are just like that. People want to show off their wealth, get ahead of others, and be bigger. They always want more and will never be satisfied.

  <[]> Yeah, as I said, they want more and sometime they will destroy the nature or surrounding environment to get what they need and that's sad because the rich and powerful are so powerful that the law is useless against them. They don't care about how they will be punished in the afterlife.

  <[]> Well, obviously the police needs to be tough on the powerful and influential, but that again can be hard for the police considering the circumstances. However, the government should do something because the gangs will use the money from illegal forest activities to expand their members and influences and may transfer to other crime activities".

- #P27-EXP – *"I think the nature works in similar way to 'the duck with golden eggs' story. You would be able to collect a golden egg from the duck continuously every day, but if you get greedy and rush the duck, the animal will die and you will get nothing at all".*

  <[]> I think the problem is that people are so selfish. Our roads and cities are expanding into natural habitats. It's impossible for wild animals to defend their homes against humans. Elephants, for examples, are the symbol of our country. However, elephants are being

hunted down for their tusks. Also, many elephants are being cruelly trained to entertain foreign tourists for profits".

<[]> I think we should return some lands back to the nature. After that it should be written in the law to prevent anyone from surrender the lands for human uses again".

2.1.1 Who do you think is responsible for the forest protection?

The government should be responsible for forest protection:

- #P2-CTRL – *"I think the law must be able to prevent powerful people from invading the forests".*

- #P3-EXP – *"The police needs to be tough on this problem. Like, cases about powerful politicians and businessmen cut down the forests to build resorts or farms. Just send everyone who violated the nature to hard labor camps like we did hundreds of years ago and the issue will be far less problematic, well that's my opinion. But, to be honest, I don't think we would be able to do that".*

- #P21-CTRL – *"I agree with enforcing the law around forest areas. The forests are national resources and should not fall into the hand of someone. <[]> The law must be enforced to deter illegal logging business and hunters.*

  Also, I want the police to regulate traders around the forest areas. It's like having big parties around natural reserves these days … with loud music, advertisements on forest products, and garbage left by tourists. In my youth, people want to visit natural reserves because they want to get a quiet relax without being disturbed by the noises".

- #P40-EXP – *"I think the government needs to solve this problem quickly. We need to punish environmental polluter. This is not about being hippies. This is about protecting the world for our children and many generations to come. We should be serious about this because destroying the nature is destroying the world … perhaps worse than world wars. I think good officers can be compared to white blood cells trying to keep the diseases at bay".*

The public should also be responsible for the forest protection:

- #P51-EXP – *"It's the government's responsibility to protect the forests and natural landscapes. <[]> I mean we have forest protection officers and soldier to do that. It's not something that ordinary people can help directly because we live far in the city.*

But citizens should not support illegal logging by refrain from buying furniture produced from rare wood like teak".

- #P16-CTRL – *"... the law must be enforced especially on heavy industries. People should help by notice the government of suspicious behaviors too".*

- #P22-EXP – *"... I like the idea of having superstars or role models to promote environmental conservation. That might be the start to draw teenagers to nature. I've heard about the government official who plant hundreds of tress though. Government officials should devote themselves for the public like this policeman[1], not just sitting around at work. I'd promote and reward him for his efforts if I were his boss".*

Supporting donation for forest protection

In support of donation towards environmental protection, some participants have noted that:

- #P7-CTRL – *"... Sometime, environmental organizations have visited my office building couple of times a year and I've donated small amount for them. <[]> I think helping the world is as good as helping people in needs".*

- #P10-EXP – *"... I support wildlife and forest protection projects ... although my contribution is small. I think people with financial capacity should donate to protect the environment, but the government should be able to show some good works to the public too".*

- #P40-EXP – *"... Donation should be made toward environmental protection. <[]> I also donate my money to an office of a forest organization in the university too. Also, people should help the environment in any ways that they can. There are beautiful places in our country and I would hate to see them ruined by pollution".*

Disagreement / tentativeness towards donation for forest protection

- #P2-CTRL – *"... People can donate their money for conservation projects. It doesn't have to be big money I mean if one million people donate [10 pence] each then we will have a lot of money".*

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[1] the participant may have referred to Lt. Vichai Suriyuth, the police officer (now retired) who has earned public attentions during 1998 for his efforts in planting trees in a draught-affected area in Sri-Sakhet province of Thailand during his free time - eventually increase tree density in the area and improved the livelihood of the locals. Some reports have estimated that he had planted more than 2,000,000 trees to date.

But I don't think money alone is going to solve the problem. As I said, corruption is the main concern. I've heard a lot of reports about powerful politician converting forests into resorts and farms and nobody can do anything about it … or maybe the legal process is just too slow. Actually there was a case many years ago about a local leader who tried to rally up the mob to protect the forest but ended up being shot and the police couldn't find the assassin".

- #P3-EXP – *"… I don't like donation because I don't really know if the money is going to be put into the good use or not. What I think better is for people to gather and doing something good for the environment like clear garbage off the street or doing recycle or plant the trees … that would be better".*

- #P51-EXP – *"… I've received letters from conservation groups asking me to donate money for forest conservation projects and I used to donate some money for the cause, but I'm still receiving news about forests are being destroyed at the same time. So I'm starting to question the performance of forest protection".*

- #P57-CTRL – *"… Sometime they want you to donate like [£2-5] every month and the money will be taken from the account automatically. I think it's so weird. It's my money and I should be able to do it without any commitments. Besides, I don't feel safe linking my bank account with someone else's".*

- #P69-CTRL – *"… [I don't want to donate] because I've had a bad experience with the representative before.<[]> Well, they came to my house and asked for donation. My sister said she did not have the money at the moment and so they said bad words to her. <[]> I don't know … maybe they were pissed that they didn't get the money".*

- #P79-EXP – *"… No, I wouldn't donate. I'm not sure if the money is going to be used appropriately. It would be a shame if the money would just end up in someone's pocket. I would prefer to donate in order to support the family of officers who have been injured or given their lives protected the forest".*

- #P39-EXP – *"… I would donate money sometime, but don't want to do often. To me, it's kind of making bad habits … I've heard about some temples that received a lot of money from donation then the monks decided to take away some money as their own so you can see my point now. My suggestion would be that the forest protection officers should work harder … or the government should divert more resources for environmental protection projects.*

They got money from our tax so they should be doing their jobs without demanding for more".

People can help on environmental projects though. People from my division have participated in beach cleaning last year. We collect a lot of garbage like plastic bags and water bottles. It was a good experience and I think we enjoyed it … kind of having an extra day off with colleagues and we also did something good too.

<[]> My boss said that we will be planting some trees this year. I think other companies should do something similar. It promotes relationship with colleagues and makes people care more about the world at the same time".

2.2 Pollution issue

A participant has recalled about water pollution by referring to his personal experience with water pollution. When asked about the source, the participant has recognized water pollution generated by factory (i.e. point-source), but did not mention water pollution from non-point sources (i.e. households and farmlands). When asked about the solution, the participant has suggested education and environmental awareness as the mean to decrease water pollution problems

- #P4-CTRL – *"Water pollution can cause great pain. I was hospitalized once and the doctor said that it was caused by drinking polluted water … I didn't detect any difference in smell and taste. <[]> If we see a lot of dead fish or change in water color then it's likely that the water is polluted, but we can't because we drink from the tap for most of the time.*

  <[]> It must have caused by careless factories that released wastewater into the river. Sometimes the government has ordered factories to shut down because people in the area were admitted to the hospital [after drinking polluted water]. <[]> The locals are still depending on water from the river [instead of using tap water].<[]> We need to teach people [on the importance of water] so they would stop polluting the water".

A participant has recalled about water pollution by referring to media portrayal of negative health impact from drinking polluted water. The law enforcement and new technology (tech-fix) have been suggested by the participant as solutions to the problem.

- #P21-CTRL – *"I've seen pictures on the internet about people in Africa dying from drinking polluted water. <[]> Unless scientists would come up with new technologies, I think water pollution problem as well as other pollution problems will continue to magnify. Also, the*

government needs to control the quality of drinking water and punish those who pollute water sources".

Another participant has recalled from his personal experience about water pollution in the canal. Negligence by both the locals and business has been cited by the participant as the source of pollution. Similar to many crime issues, the participant has considered law enforcement as the solution to the problem. Further, 'name & shame' tactic was offered by the participant as a deterrent to combat environmental crimes.

- #P16-CTRL – *"I was in a canal boat on my way to the office when I see streams of wastewater being poured from the construction site right into the canal[2]. It was not just the big business because food vendors by the canal also pour buckets of food scraps into the river. People from the slums would throw their garbage into the river too. I can't be the only one seeing this.*

  Other passengers in the boat also look at the same way, but there's nothing we can do about it. <[]> I think the police should be able to prosecute them. Maybe someone should snap some photos as evidences for the police and put them on the internet".

Similarly, another participant has recalled from his personal experience about water pollution from the industrial sector. When asked, the participant has suggested the authority as the solution for industrial pollution problem. The participant did not discuss on pollution from the residential areas, however.

The participant has also extended to suggest public transportation as the solution to reduce air pollution problem.

- #P76-EXP – *"When I read about water contamination, I think about garbage and pollutants being released into the river. … My group was in the meeting at the client's factory. The factory was discharging wastewater into the river while we were touring the other side of their factory. I think our guide was embarrassed by the event that he had to divert the tour to other section of the factory.*

  <[]> I think the fault rests with the factory owner because it was a selfish act to discharge the wastewater at the cost of the locals who live nearby the river. The local authority is also at fault for not punishing the factory for violating the law. <[]> I think what we can do [to

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[2] The discussion has revealed that the participant was referring to San-Saeb river – a highly polluted canal system in Bangkok used mainly for transportation.

reduce pollution problem] is conserving water resources. Also, people can use buses to reduce air pollution".

A participant has recalled about air pollution from the traffic and buildings. When asked about the solution, the participant appeared to consider new technologies as the problem solver (i.e. tech-fix).

- #P5-EXP – *"Air pollution makes people sick and there's a chance for us to get lung cancer. The air quality was much better 10 years ago. The number of cars and buildings are increasing as well. <[]> The scientists need to create a new technology to eliminate pollution problems. Maybe they could come up with a technology that would collect and condense the pollutants then neutralize them".*

A participant has recalled about toxic pollution from industrial wastes. The participant's attention seemed to be directed towards large corporation. When asked about the solution, the participant has considered law enforcement to be an option.

- #P30-EXP – *" Dumping of toxic wastes can be very hard to deal with because it they are big corporations and workers would dump the waste during the night and they would make sure that no one is looking at them.*

  <[]> I don't think we would be able to arrest all of them. However, I believe we can still impose heavy penalty to discourage them to do so <[]> It is important that the law should deal with small business and commoners too, but I think it is more important to deal with the big business first. If the government could show everyone that they can deal with the big business then others will not dare to take risks".

Another participant has recalled about pollution from pesticide used in rice paddies (the methane emission from rice paddies was not discussed by the participant, however). The participant has recognized the negative health effect from pesticides on the environment, producers, and consumers (although the impact on the natural environment was discussed in minor details when compared to health impact). As with a number of environmental and social issues discussed, the participant seemed to rely on the government when asked about the solution.

- #P11-EXP – *"I didn't know that growing rice can generate pollution as well. I always see rice as a plant. <[]> I think pesticide is bad for not only the environment, but also the consumers and the farmers as well.*

<[]> I think we need to come up with a food standard. The Food and Drug Administration should take care of food quality".

2.1.2 Pollution issues as the side topic

The water pollution issue was highlighted by a participant while discussing about water conservation.

- #P47-EXP – *"I think it's very sad to know that a lot of people have died from drinking contaminated water. This problem can't be any better for animals and the [water pollution] was caused by our activities. People should use water wisely and there must be some ways to separate wastewater from the river until the wastewater can be treated properly".*

Another participant has highlighted about the air pollution caused by cooking activity while discussing about 'food safety'.

- #P20-CTRL – *"... Some street food vendors would grill food in the open air, releasing a lot of smoke into the air. There are a lot of street food vendors in my area and the locals cannot leave the windows opened all day because of the smoke and oil fumes. <[]> I'd say food vendors should find ways to reduce the amount of smoke released".*

A participant has referred to the toxic pollution on the natural environment while recalling about 'natural conservation'. Similar to #P4-CTRL, the participant has recognized the pollution problem originated from a point source (i.e. factory), but did not mention about pollution problems originated from non-point sources. As with a number of participants discussing about environmental and social issues, the participant considered the authority to be the solution to pollution problems.

- #P9-CTRL – *"I think we should do something about the pollution problem. The government should control industries from releasing pollution into the environment ... ".*

Another participant has referred to pollution runoff from farmlands while recalled about the concept of robotic spider from the game (using robotic spiders as an alternative to toxic pesticide for agricultural pest elimination).

- #P14-EXP – *"I am guessing that these robots can just tear pest insects apart without relying on pesticides? <[]> [If harmful pesticides are not involved] then we would be able to decrease pollution from farms as well as label these products as organic and sell them at premium price.*

Another participant has referred to the illegal dumping of garbage into the river while discussing about garbage issue.

- #P71-EXP – " ... *Then toxic content is released from the garbage dumped into the river. A lot of fish have died. We could have used those fish to feed people*".

Another participant has recognized about air pollution generated by heavy machinery while discussing about an automated food processer.

- #P48-EXP – "... *However, I assume that these machines will use considerable amount of energy which contribute to air pollution as well. So we should compare the advantages and the drawbacks carefully ...*".

Another participant has recognized the benefit of using public transportation to reduce pollution.

- #P51-EXP – " *I think [public transport] is a good and efficient system especially in city area so we can reduce high pollution ...*".

Similarly, another participant has recognized the benefit of carpooling on air pollution reduction.

- #P60-EXP – " ... *Sometime it's easier to drive for grocery shopping than taking a bus. Besides, neighbors going to the same location can be in the same car. That would save fuel cost and minimize air pollution at the same time*".

2.3 Public transportation

A participant has recalled about public bus service. Safety, reliability, and slow speed issues seemed to be the main concerns for this participant. The participant has used a developed country as an example of how the public transport in Thailand could be improved.

When asked about the possibility of improvement, the participant has suggested law enforcement to be used in order to alleviate traffic congestion problem. Further, a negative reinforcement for private car users (congestion charge) has been suggested by the participant as the mean to encourage commuters to use public transportation system.

When asked with a specific follow-up question, the participant has expressed that he would drive until the improvements have been made to the public transportation system.

- #P1-EXP – "... *I've travelled to some countries and their public transportation system is something we could learn from. <[]> Take Germany for example, they have an efficient public transportation system so many people are using them and there's not much traffic*

congestion problems over there. If you ask me, our public transportation system is in a pretty bad shape and needs to be improved.

<[]> It's unsafe, unreliable, and take a long time to reach destination. <[]> There are few things I can think about. First, traffic rules must be enforced so we would be able to decrease traffic congestion as well as accidents. Secondly, I think we could charge people the extra fees for driving cars during rush hours. That way, we encourage more people to use public transportation

<[]> [If provided with free fuel] then I'd drive for now. I'd rather wait for the government to improve the public transportation system first".

A participant has reported that he uses the sky train on daily basis. The benefits of the sky train as described by the participant included good service quality and speed, but criticized the relatively high price[3]. The social value of driving private vehicles was highlighted by the participant in brief details. When asked with a specific follow-up question, the participant has expressed that he would still use the sky train in order to avoid traffic congestion.

- #P39-EXP – *"I travel with the sky train to my office on daily basis. Sometime I use sky train on weekends for travel to the shopping centre too. I think the service quality of the sky train in our country is quite good. The price is a little bit too high in my opinion, but overall I think it is the best option right now. You can avoid all the traffic congestion in the street which saves a lot of time. Now I can sleep for longer at night because I don't have to wake up early to catch buses to the office.*

  <[]> I used to work and live in other part of Bangkok. I didn't have access to the sky train back then and it took me like 2.5 hours on the bus because of the traffic congestion. Now I can hire a local motorcycle service to drop me at the sky train station and arrive at my office within 30 minutes.

  <[]> Yeah, I know some of my colleagues would choose to drive to work. It is so expensive. You need to pay for the gas and parking. I used to convince them to use sky train like myself, but they have declined … They said it would be more convenient for them to drive. … Some of my friends need to have few drinks with friends after work so it might be too late for them

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[3] Using 2011 exchange rate, a 2013 study using Purchasing Power Parity Adjusted (PPP-adjusted) has revealed that under certain circumstances, the fare for sky / underground train in Thailand can be slightly more expensive when compared to sky / underground train of other cities / countries in the region such as Shanghai, Hong Kong, Singapore, and Japan (Whereisthailand 2013).

to catch the last train. However, I personally believed that some of them use cars to show off their social status.

<[]> Even if provided with free fuel I would still choose public transportation anyway. I don't want to experience the stress of having to drive myself".

Another participant has discussed about Bangkok canal boat service in details. The benefits of using the boat service as highlighted by the participant include: low-priced, availability, convenience, and speed. However, the participant has criticized poor water quality in the canal, crowded environment, the requirement for dexterity (getting in and out of the boat in a short period of time), and the possibility of sexual harassment in the crowded environment as the drawbacks.

At the same time, the participant has criticized the bus for slow speed (caused by traffic congestion), poor timetable, and safety concerns.

Similar to #P39-EXP, the participant has highlighted briefly about the social value of using private vehicles. However, the participant has also suggested that low-availability of buses and traffic congestion might be the reasons that prevent some commuters from using public transportation.

When asked with a specific follow-up question, the participant has expressed that he might drive, but would choose high-speed public transportation systems such as sky trains, underground trains, and canal boats over driving. Apart from driving, the participant also recognized shortage of parking spaces as another issue for private vehicle users.

- #P46-CTRL – *"I used to live near the boat jetty and it was very convenient to use the boat. <[]> Canal boats are fast and cheap and there are lots of boats so you don't have to wait around for long. I can just walk a short distance to the jetty and the boat would take me to any major districts in Bangkok.*

  <[]> I'd only complain about the smell of the water and the way the staff squeezes people into a single boat. <[]> Yes, I've heard that some people especially women and the elders are having troubles jumping from the boat to a jetty <[]> because the boat won't stop there for long. But I've no problem with that because I've been using it for so many years. Also, I've heard that some women have been sexually harassed while in the boat because a lot of people will be squeezed into a boat and sexual offenders will use that opportunity.

<[]> I have now moved to a new office and this one is far from the canal so I have to use bus now. <[]> [With boats], I used to spend only 20 minutes to reach the office, but now I'm spending more than an hour on the road. <[]> [buses] never arrive on time, the traffic congestion is so bad, and many bus drivers are careless on the road. I don't like using buses.

<[]> [If provided with the free fuel] then I'll choose to drive [rather than using public transportation]. However, I'd choose boats, sky trains, and underground trains over driving … anything apart from buses will do nicely.

<[]> They are faster and even if provided with the free fuel, it would be so hard to find an available parking spaces especially on weekends. I was once sat with my friends in a car and we had to wait like 15 minutes for an available parking space in a shopping centre.

<[]> I don't think we could blame people for not using public transportation. Of course, some people want to use cars to show off their social prestige, but for some people they really have no choice. Maybe they are on tight schedules and cannot wait for the buses because buses are often slow [due to traffic congestion]. Or maybe it's because there's no bus stops or train stations in their areas. I think the correct question would be why can't we have efficient transportation system like in many developed countries?"

Another participant has noted a perceived negative public opinion against public transportation as the reason for not using public bus services. Also issues such as poor service quality and low service availability have been noted by the participant (in agreement with the account provided by #P46-CTRL).

Interestingly, the participant has noted few key advantages of using motorcycles as the private vehicle of choice rather than using private vehicles – namely lower fuel consumption and motorcycle's ability to avoid traffic congestion. In agreement with #P1-EXP and #P46-CTRL, the participant has suggested that the public transportation system should be improved – with a special concern over the safety of public transportation.

- #P79-EXP – *"I think the problem is that many people still seeing public transportation system as the travel option for the poor. The service quality is poor though. Many drivers are very rude and on many occasions … drunk. I think these are really upsetting problems.*

<[]> I used to take the buses, but then I gave up and ride a motorcycle instead. <[]> There aren't many buses in my area and sometime I had to wait for almost an hour for the bus to arrive. Sometimes the bus drivers don't even notice a person standing in wait at the bus stop.

Also, the traffic is always bad and I rarely get to sit on the bus because there are so many passengers in the bus.

<[]> [Motorcycles] can be very convenient because I can just slip through the traffic without problems. <[]> Of course, [I have to pay more for the gas], but it's still a lot cheaper when compared to driving cars plus motorcycles are much faster too.

<[]> I'd love to use public transportation and I'm sure a lot of people want to use it too, but first the government really needs to improve the system. <[]> Maybe they can use CCTV to monitor the traffic and safety of transportation system too".

Another participant has expressed his support toward public transport improvements / expansion. Price and reliable timetable has been suggested as the main problems for the current public transportation system. The advantage and disadvantage of using private vehicles have been discussed by the participant (high-speed as the main advantage, but at the expense of high fuel and parking cost).

In participant's viewpoint, corruption was one of the factors impeding public transport development. However, the participant has suggested that the government would be benefited financially from the revenue generated by the public transportation system while the public would be benefited from high-speed public transports. The participant has also suggested building parking spaces near public transport hubs to encourage the use of public transportation.

- #P55-CTRL – *"If we have efficient public transportation system at reasonable price then I believe that people including myself will want to use them. <[]> The problem is that timetable for public transportation is unreliable. Sometime you have to wait for half an hour for the bus to come. I think it's important that we need to expand sky and underground train networks because it's now limited only to city centre area.*

  <[]> I've been pondering this ... if I take the bus from my home to my workplace it would take about 1.5-2 hours depends on the traffic and the time I wait for the bus to arrive . On the other hand, I would spend about 45 minutes driving a car. However, driving will cost me a lot more for the gas. <[]> I estimates that I'll be cashing out about [£4] a day for the gas and parking. It would be faster and cheaper to take the trains to the city centre ... although it would definitely be more expensive than taking a bus. But imagine this ... once office workers start taking the train, traffic congestion will be less problematic, buses would be able to reach destinations faster, and the government would get revenues [from the public

transport] too ... We should have [efficient public transportation system] by now if not for the corruption problem.

<[]> [If provided with fuel and parking space] then I'd choose driving. However, if the traffic congestion is heavy then I'd choose sky or underground trains if possible.

... The government should consider build more multiple-story car parks near public transport hubs so that people can just drive a short distance, park their cars then jump on trains."

Another participant has identified poor management, poor speed, poor service, and security concerns as the problem for public transportation system. According to the participant, technology especially computer and communication system could be used to reduce operational cost as well as improve the service of public transportation system.

- #P56-EXP – *"... I think the problem is due to poor management. Buses are very slow and often stuck in the traffic. Many drivers are impolite and drive carelessly. Accidents caused by bus drivers are not uncommon. New management policy and technology could be used though. They could use computerized coin boxes so they don't have to hire coin collectors[4] and ticket inspectors. They could have saved a lot of operational cost this way. Alternatively, this extra revenue could be used to hire better drivers.*

  <[]> [For buses that charge transport fees by distance], the computer software could be programmed to calculate the fee easily. We have a similar system for [Bangkok Sky Train] so I don't see why it's not possible to apply the same principle to bus and boats?

  Also, I think computer system could be fitted on the bus to track drivers' driving performance. Drivers will feel the pressure of being monitored all the time and will drive more carefully. This means accidents will be reduced and more people will be interested in using public transportation system.

  <[]> [If provided with free fuel then] I'd choose to drive, but if the government decides to renovate the public transportation system then I will drive less and use buses more. <[]> I wouldn't bother to drive all the time".

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[4] Coin collectors are hired by Bangkok transport buses (BMTA) to collect transport fees from the passengers. Apart from the driver, each bus has one coin collector.

Another participant has commented on the issue with the smart payment system[5] after recalled on the carpool policy. The participant has recognized both the environmental and financial benefits from utilizing the information technology.

- #P43-CTRL – *"... people are supposed to pay their bills easily [at nearby convenient stores] would help the environment and save time.*

  Occasionally however, your payment won't be delivered to the electrical and water authority and they will charge you for the delayed payment ... Yes, we get the receipt for each payment, but it will take weeks or months for them to sort out the problem out then it will take another month or two for them to return you the 'delayed' payment.

  It's such a trouble and I'm not the only one who experienced this issue. Everything should be simple and computerized in this age .... The problem has been around for years now and they still can't get it fixed.

  ... So I figure it's better for me to ride miles away from home just to pay the bills. It's not worth the headache".

2.4 Recycling

A participant has recognized the benefit of recycling in reducing garbage problems. The participant has suggested rewards as incentives to encourage the public to practice recycle. However, the participant has reported that he couldn't practice recycling due to unavailability of recycling facility in his accommodation. Further, the participant's statement has also suggested that the aspect of time and effort are other factors influencing his recycling activity. This could be linked to 'other things are more important' stance as highlighted by Centre for Alternative Technology (2010: 158)

- #P4-CTRL – *"I think people should practice recycle in order to reduce garbage problems. <[]> I think the government should give some gifts to those who practice recycle. <[]> Maybe the government could give small gifts to people randomly .... On the second thought, each village could vote for people who practice recycling frequently. After that we draw a lottery. It doesn't have to be a big money, but we should spread the opportunity for many people to win.*

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[5] This system allows the citizens to pay their utility bills at the nearby convenient stores (at a small fee) in order to save the trip to local electrical / water authority buildings. Therefore, saving their time and fuel.

<[]> [I don't practice recycling because] there's no recycling station in my apartment. <[]> If I have time I'll do it. But it would be good for the apartment to put the recycle bin on each floor as I don't want to carry recycles down to the ground floor every time".

Another participant has recalled some of recyclable items. Further, the participant has noted the superiority of 'reuse' over 'recycling'. The participant has reported that she does not practice recycling on daily basis. According to the participant's statement, bargaining with waste dealers appeared to be the main reason for her to practice recycling while environmental benefit was recognized by the participant.

- #P7-CTRL – *"Recycled materials can be reused again ... things like metals, plastics, glass ... and paper can be recycled. However, if we reuse things like plastic water bottles then it would be better because we don't have to melt plastics in the first place ... we don't have to use fuel to transport them to recycling stations.*

    <[]> I do recycling sometime. <[]> Like, 50% of the time and I sell them to waste dealers. <[]> Sometime I forgot to put recyclable into my recycle waste box <[]> Not a good money, but it's better than nothing. Plus you feel happy doing something good for the environment at the same time".

Another participant has reported that her family has practiced recycling 'quite often'. The participant's account has highlighted a degree of uncertainty about recyclable items. Social responsibility has been cited as the motivation for her family to practice recycle.

- #P11-EXP –*"People should do recycling when they have time. <[]> It would be better to sort the garbage all the time. But that won't be possible because some people are too busy and some people won't be doing it at all.*

    <[]> My family do recycling at home we separate bottles, metals, used paper, plastics from food waste. However, some people said I should put used kitchen towels in recycling bins too … not sure about that one though.

    <[]> There's no waste dealer in our area so we just give them to garbage truck. <[]> [we do it because] it's social responsibility, I guess. <[]> We didn't do it every time though".

Another participant (an apartment manager) has reported that he encourages his tenants to practice recycle. According to the participant, some of his tenants lack the knowledge about recyclable items. The motivation for his tenants to practice recycle, as reported by the participant, appeared to stem from social compassion rather than environmental reasons.

- #P72-CTRL – *"So I bought this [large] bin couple of years ago and told the occupants that they should put recyclable wastes in this bin. <[]> Not many people cared about it during first months, but few people including myself continued to do it anyway. Then I notice more people have started to join us. Some people got confused about what can be recycled and what should be put in general waste bin.*

  <[]> Not everyone has joined us on the recycling though. <[]> I'd say about [50%] of people in this apartment practice recycle.

  Many people have joined us in sorting their waste once we start giving out all recyclable wastes to a local waste dealer. <[]> We give our recyclable wastes to him for free … It would be too complicated to divide the money [earned from the selling of recyclable wastes] and I can't keep all the money for myself. The dealer also helps us with odd jobs for free sometimes. It's like helping each other out".

Similarly, another participant has recognized the benefits of environmental conservation as well as the danger from toxic waste. According to the participant, social responsibility was his motivation for practicing recycles. Interestingly, the participant also appeared to be motivated by religious reasons as well.

- #P60-EXP – *"… It's social responsibility for me. <[]> Like, you can do recycle to help keep the world clean and prevent people from getting sick at the same time. I think it's a sinful act if you don't do it simply because you're too lazy to do it … that is negligence and gods will punish you for that". <[]> Some stuff like batteries and broken light bulbs can injure waste collectors if you mix them with general wastes".*

Interestingly, another participant has noted the environmental benefits and improved efficiency of the public works that could be gained from recycling. However, the participant has reasoned that the value of recyclable waste would motivate garbage collectors to sort recyclable wastes for their own profits, and thus, his reason for not practicing recycle.

- #P13-EXP – *"I think recycling will help save the environment, save resources, and speed up waste processing. <[]> No, there's no need to sort the garbage by yourself, waste dealers and garbage collectors usually browse through piles of garbage finding recyclable waste for sale anyway".*

Similarly, another participant (an apartment manager) has noted the practice of waste dealers in her area as the reason for not doing recycle.

- #P21-CTRL – *"I think only few of my tenants would sort things like beer cans and bottles for recycling. <[]> Well, the city provided a bin for us, but still ... not many people would do it. It could be because people don't get anything in return. It's also wasting their time sorting garbage.*

  ... The waste dealers around here would help themselves by picking up recyclable wastes from the bin even if you mix all kinds of garbage in there".

However, a participant has stated that he is no longer practice recycling due to the perceived inefficiency in waste processing.

- #P68-CTRL – *"... I've stopped sorting the garbage when I see [garbage collectors] put all the garbage in the truck. There's no point in that".*

Another participant has recognized the importance of environmental benefits from recycling. However, the participant has admitted that he is not participated in recycling activity due to inconvenience and time constrains. When asked about waste dealers, the participant has also reported his negative attitude towards waste dealers for their practices and therefore, his reason for not to deal with waste dealers.

Finally, the participant has suggested that recycling activities should be carried out in manufacturing sector. This could be linked to 'other should lead' stance as highlighted by Centre for Alternative Technology (2010: 155).

- #P43-CTRL – *"Recycle is important so we can reduce resources consumption and pollution problem. <[]> The recycling station is too far from my house and I don't have time to do it.*

  <[]> Some waste dealers have come and rife through the bin in search for recyclable wastes. I wouldn't mind that, but I can't stand the way they have scattered the general waste around and littered the street. They won't even put the bin back to where it belongs after they have finished. It's so much easier for me to just put everything in a single bin and give it to the garbage truck.

... Probably recycling is useful for large companies since they produce a lot of wastes".

2.5 Garbage issues

A participant has recalled and discussed about the recent oil spill accident in Thailand in both environmental and economic context. Re-use and sustainable lifestyles have been suggested by the participant as solutions to reduce garbage issue.

- #P30-EXP – *"The game event of marine disaster makes me think about the recent oil spill accident that caused a major economic loss for the beach area due to declined tourism ... and not to mention about animals that have perished in the accident.*

  <[]> [in order to reduce garbage problems] we ordinary people should re-use things like plastic containers and not to buy unnecessary items".

Another participant has recognized marine garbage / pollution's detrimental effects on the ocean. The discussion, however, also directed towards overfishing issue. The participant has also recognized about the growing population issue, the importance of marine economy, as well as health implication caused by irresponsive fishing practice.

It appeared that the participant has already possessed environmental awareness from his familiarity with fishing business.

Similar to many participants' responses on forest and pollution issue, the government / law enforcement was cited by the participant as the solution to the marine garbage problem.

- #P38-CTRL – *"Garbage is a serious pollution problem ... along with industrial wastes being released into the ocean, overfishing and demands for seafood. Animals are dying from the pollution, we are harvesting seafood faster than animals' reproduction rate, and we have a lot of people in this world to feed.*

  My family has been operating 2 fishing boats in Rayong province since my grandfather's days. I remember the crew would come back to shore in several days with the boat full of fish, crabs, squids and shrimps. Fishermen even gave away some low-value fish to the locals for free.

  Now things have changed. Fishermen need to be at sea for weeks and they can't even catch the same amount of fish like they used to. On top of that, they can only catch small amounts of high value fish. Some groups of fishermen are using formalin to keep the fish fresh while they are at sea and you know this is very bad for consumers' health. <[]> We haven't make good profits these days. Actually, one of our boats is now in the dry dock because the upkeep is just too much [to sail the boat into the ocean without good catches in return].

  <[]> The government must eliminate illegal fishing and marine fouling. I don't know how to decrease the demand for seafood, but if we can do it then we might probably save the fish population for the future".

Another participant has recalled about electronic waste. The participant has recognized the benefits provided by electronic devices as well as negative effect from electronic wastes. However, when asked about the solution, the participant has suggested technology as the prospect solution for garbage problems (i.e. tech-fix).

- #P57-CTRL – *"I've seen many new technologies and they can do incredible things. However, people's demands are becoming greater. Twenty years ago only few people could have computers at home, but now many people have computers at home and almost everyone own a mobile phone. Then you see things like old batteries being thrown away. It's like a competition between new inventions and increasing garbage problems.*

  <[]> Perhaps the scientists might come up with a technology to process the garbage into usable material again. <[]> If not then it seems like people will continue to use resources until we don't have anything left. One way or another, I think we will come up with a plan to prevent the world from collapse".

Another participant has recalled about the negative impact of garbage on wildlife caused by tourism activities. The participant has recognized the economic incentive from garbage reduction. Similar to #P38-CTRL, the participant has suggested law enforcement as the solution to garbage problems in natural reserves.

- #P60-EXP – *"... I've heard about some wild animals have died from ingesting garbage too. <[]> I think eco-tourism should be promoted by enforcing the law and prevent both the locals and tourists from damaging the nature for personal gains. Tourism has been an important part of our economy".*

Another participant has emphasized on the plastic waste problem and referred to the recent report of garbage mismanagement and its impact on health and welfare issues. The participant has suggested plastic waste reduction as the solution for garbage problem. Additionally, the participant has suggested law enforcement as another solution for garbage problem.

- #P71-EXP – *"I think people have used and throw away empty packages and because plastics are hard to degrade so the garbage problems have become a serious issue. There was a report last week about people burning large garbage piles, but the fire and the smog was too much too contain and villagers have been evacuated from the area.*

  <[]> I think we should at least reduce plastic wastes. Perhaps we might be able to refill empty plastic containers in the future and that would reduce the garbage problem. Also, the government should deal with those who dump garbage illegally".

Another participant has recognized the relationship between population size and increasing garbage problems. The participant has referred to the 'Alternate animal feed' (an in-game concept of feeding agricultural and food waste to farmed animals) as a solution for organic waste problem.

In participant's statement, the inorganic wastes (such as plastic waste) then could be reprocessed into the new product. However, the participant did not discuss about environmental impacts from such activities (pollution and energy consumption).

- #P22-EXP – *"It is a big problem because we now have more people on earth <[]> I think we could sort out organic from inorganic waste. Then we could use organic waste as the fertilizer. Or we could feed it to animals like in the game, right? <[]> [For inorganic wastes] they should be sent to recycling station where things like plastic and glass could be melt down to make new products".*

Another participant has recognized the environmental impact from plastic and electronic wastes. The participant's statement has suggested that he expects the new technology to solve garbage problem (tech-fix). The participant has given few examples on innovative products – indicating his awareness on new technologies.

However, it should be noted that the utilization of bio-plastic (as recalled by the participant), also contribute to negative environmental impacts as noted in a study by Tabone, Cregg, Beckman, and Landis (2010).

- #P64-CTRL – *"I think garbage problem is very important. <[]> Like, plastic and electronic waste are quite worrisome because they take a lot of time to degrade. However, I've heard about the development of bio-technology like using plant-based plastic which can be dissolved safely in the environment.*

  <[]> I've also heard that some countries are developing a technology to turn plastic waste into something useful and that might solve a lot of garbage problems in the future. However, I don't know about electronic waste since we have yet to find the solution for it and people are very depended on electronic devices nowadays".

3. Top 5 social topics

3.1 Crime

A participant has referred to the concept of juvenile detention centre from the reading material. The participant has discussed about serious crimes conducted by teenagers such as grievous

bodily harm and rape. Severe measurements have been suggested by the participant as the solution for serious crimes committed by teenagers.

- #P72-CTRL – *"... I think many teenagers are very violent these days. I've heard about teenagers who knifed people for money. Sometime 15-16 years of age male teenagers also participate in gang rapes as well. It is as if they know that they will be punished leniently for their crimes [due to their age].*

  <[]> I think such vicious crimes should be treated with the same punishment as adults. I can accept that 10-year-old boys might hurt other people because they are too young. However, the chance for them to actually kill someone would be slim because they are small in size. In my opinion 15-year-old teenagers should be able to responsible for their actions and they should be penalized in the same way to adults if they commit serious crimes. In the past, most people around 15 would be able to get married or work for themselves so they should be considered as adults".

Another participant has referred to the game concept of marine platforms, and non-lethal anti-piracy device on board cargo ships. The participant has expressed his inadequacy concern for the device and suggested that lethal forces should be used in conjunction with the non-lethal device. Also, the severe penalty has been suggested as a solution for the maritime piracy.

- #P81-EXP – *"I like the idea of using non-lethal weapons on board the ship to fight off pirates, but I think the shipping company will also need to combine the technology with other weaponry and also hiring mercenaries to guard their ships.*

  <[]> I think piracy is a serious crime. I've read about the crew being held as captives for months or even years and their families need to pay a lot of ransom money in exchange for the captives' freedom.

  <[]> I think if we can deploy warships or build networks of defensive platform like in the game then we would be able to deploy helicopters or robots in response to distress calls from the cargo ships. <[]> If a pirate is captured, s/he should be given a choice to be executed like in the past or an alternate sentence of working as a hard labor for the rest of his/her lives. <[]> Serious crimes should be met with serious punishment".

Another participant has recalled about crime issue from the game. The participant has also referred to a case of crime from his personal experience. Similar to #P72-CTRL and many participants who've recalled on crime issue, severe punishments have been suggested as the solution to crime problems.

- #P5-EXP – *"... A robber snatched a handbag from my friend and she had received injuries from the attack. Everyone was in shock ... we tried to restrain him, but he was too powerful and ran away. <[]> It was in late night and no one was nearby.*

  <[]> The robber should be locked up in the jail for a long time because not only that he stole from her, but he had also injured her quite badly as well. On top of that he should be ordered to compensate for her. Well, [if the robber doesn't have enough money] then he might as well sell one of his kidneys to get enough money. <[]> There's no need to be lenient on those who attack innocent people for no reason".

A participant has recalled about a rape crime from the game. When asked, the participant has suggested severe penalties as the solution for crimes. The participant has also referred to her personal experience about crimes.

- #P59-EXP – *"In my neighborhood I've seen a woman who was punched and dragged by two criminals riding a motorcycle. They were after her purse. People in the area sent her to the hospital afterward. It was said that she was so battered and needed a lot of stitches and her face will never be the same. After that I've heard that she had to quit her job because of the injury that she sustained on her face. It was terrible.*

  <[]> She had received some support money from the social department and the criminals got less about 10 years of prison sentence. <[]> They confessed and so their jail time have been reduced. I don't think this is justice because it's not worth it. The evidence was obvious so these **** should either be executed or force to work so the money that they've earned could be sent to compensate this woman. Criminals should be punished harshly no matter if it's done to a man, a woman, or a child".

A participant has recalled about crimes and drugs, then discussed about the declined moral conducts in the society. Societal reformation was suggested by the participant as the solution for societal improvements.

- #P77-EXP – *"There are many cases about crimes and drugs, but I think the most serious issue is that many people cannot discern the right from wrong. People always look up on successful business owners and influential figures. So many people are trying to get rich without caring about breaking the law or code of conducts.*

  … Not many people would look up to honest, hardworking people who tend to be less successful in term of financial capacity. Media too … they only report about famous people and sometimes they portray violent contents too. That's where our future is heading to. A

small shop owner in my hometown has been giving free meals to those in needs every day. The media should praise the shop owner for his kindness. This is what we need for our society.

<[]> Well I think everything should be reformed. Education system should be reformed, then the way we live, the corruption problem, and big corporations should be more responsible toward the society and the environment too".

Another participant has referred to the reports about drugs and crimes. Interestingly, the aspect of unsustainable family planning and its impact on the society was also discussed by the participant. In similar to many participants who have recalled on crimes topic, severe punishments have been suggested by the participant as a deterrent against crimes. Further, the participant has recalled about the concept of using prisoners as workforce in environmental conservation projects from the reading material.

- #P2-CTRL – *"... People kill others for money so crime is a very serious issue. <[]> Say, teenagers addicted to drugs and alcohols so they need the money. Then people have disputes over matters and used violence to settle the problem. <[]> I think it all started from the family, lack of family planning like having too many children can make the family poor because the parents need to spend a lot of money. When they have run out of money, some parents have resorted to stealing or harming others to get money for their families. Similarly, the children might be persuaded by bad friends to become drug addicts or become criminals.*

  There are interesting cases I've heard recently ... about a guy in some provincial areas who killed his father-in-law and mother-in-law after they've asked him to stay away from their daughter. Like, the guy was addicted to drugs or something like that. Then there was another report about a guy who killed his wife because she wanted to divorce from him. I don't know ... people seem to kill each other over petty issues these days.

  <[]> For the start, we should put the convict to serve long-term sentences. Sending them to work on environmental projects like in the book is a good idea. If they come out and do it again then the penalty should be increased and finally they should be sentenced to death. <[]> [The death penalty] won't solve the problem, but at least some would-be criminals will think twice before consider doing it. It would be good for the society because I'm sick of hearing about sending criminals to jail for the 3rd or 4th times and they come back again and again to harm others".

Another participant has recalled about criminal activities and expressed his concern about a cybernetic crime. The participant has suggested severe punishments as the solution to decrease criminal activities.

- #P8-CTRL – *"... criminals also steal people's data and money electronically. <[]> I think both physical and electronic money have their own weaknesses. I don't know ... some experts said that using credit cards are safer than carrying physical money because the technology is getting better. However, I think criminals will find their ways to catch up ... and it's not just the criminals because there are reports about corrupted bankers who collaborated with the criminals too.*

<[]> I think what we need is severe punishments for crimes that could be proved with evidences. The law should make criminals compensate for their victims fairly. Dangerous criminals will be locked up in cells that they will be too old to do anything by the time they finally get out".

3.2 Unplanned pregnancy

A participant has recalled about a case of unplanned pregnancy from the game. Long-term social problems such as welfare issue and possibility of involvement in criminal activities was highlighted by the participant. The participant has referred to his personal experience with a troubled family when asked to discuss about long-term social problems.

When asked about the solution for unplanned pregnancy, the participant has suggested education as the solution for unplanned pregnancy. Also, the participant has suggested attentions from parents and teachers as the solution for unplanned pregnancy in teenagers.

- #P36-CTRL – *"I think parental responsibility is very important. Children welfare will suffer if they were raised by irresponsible parents. Also, these children might be turned into criminals one day so they will be dangerous to the public.*

<[]> Let me tell you a story, my aunt owns a farm and we used to have a lot of problem with this troubled, non-income family living in the area. The parents and their teenage children are addicted to drugs. <[]> They live in an old barn by the edge of the village. They have been here for like ... 5-6 years now. No one really knows where they came from.

The barn used to be the property of an old farmer. [The old farmer] had tried to evict them from his land, but they won't leave so [the old farmer] went to the police. The police demanded them to leave so few days later the family threaten to kill the farmer if he force them to leave again.

Anyway, the old farmer had died of the old age not long after and his children have not taken interest in his farm plot yet … so it is pretty much abandoned to this troubled family now. <[]> The family would cut electric wires and steal from people's houses sometime to supplement their drug-addiction lifestyles. The mother would pretend insane and ask people for money. <[]> The locals know this and won't give her money so she would beg for money in other areas.

During night time, the father and two elder sons would slip into people's farms then shock the fish with electricity and steal fruits and vegetables. <[]> Some farms have dogs, but many of the dogs have been poisoned by the family to silent them. <[]> Well, it was a peaceful village before this family showed up so it's safe to say that they have been behind these troubles. <[]> Farmers in the area have caught them red-handed many times, but the law considered them as small-time criminals plus they don't have money to pay for the penalty. Honesty, I think the jails are too crowded with dangerous criminals already so the police don't feel like sending small-time criminals over there.

The good news is that the father and one of his sons are now dead. Rumor has it that the father had offended some gangsters so he was killed and the son was electrocuted one day when he tried to cut the electric wire. <[]> Well, the last thing I've heard was that the family's daughter had an argument with her mother so she left the barn and got a job as a cleaner in a local shopping mall. It's not a good job, but would be much better than living with her mother. Hopefully she'll manage her life well and take a different path.

<[]> I think the best we can do is to educate people especially those who live in the remote areas. <[]> I don't know, I just think that many people who live there like having many children to take care of their farmlands. Also, parents and teachers need to take care of the teenagers … I've heard that it's quite a problem these days".

Another participant has discussed about unsustainable family size. According to the participant, financial capacity, parental responsibility, and social responsibility are the main factors to ensure family and social welfare.

- #P51-EXP – *"Some poor parents have so many kids so they are struggling to provide for the family. <[]> I think a child is appropriate for today situation and two should be the maximum … more than this and the parents have to work a lot harder for the children.*

<[]> I think financial status is the main reason. If the parents couldn't provide money for the children then they will be hungry and won't have enough resources like other kids. They won't be able to go to school and that can't be good for their future. Apart from that I think parental responsibility is very important ... some parents have a lot of money, but don't care much about their children. That's why we have a lot of problems these days.

<[]> Say, many parents these days don't really care about the behavior of their children. Others are teaching their children to take advantage of others without consider moral aspects".

Another participant has recalled about unplanned pregnancy from the reading material. The importance of financial capacity, education, and supports from family members has been highlighted by the participant.

Government supports on sexual education was highlighted by the participant as the solution for unplanned pregnancy. Abortion was also suggested by the participant as a possible solution.

- #P57-CTRL – *"I think it's down to family's financial situation. If parents have the resources then they would be able to provide education opportunities for their children. I came from a relatively low-income family myself, but members of my family love and care for each other. We also live frugally in order to save the money. I'm glad no one in my family is involved in gambling.*

  <[]> [In order to reduce unplanned pregnancy issue], the government should educate teenagers about the consequence of unplanned pregnancy. Perhaps ... just perhaps we should consider allowing abortion for the mothers who wish to do so. <[]> I think it will eliminate problems in the long run".

Another participant has recalled about abandoned children from the game. The participant has recognized parental responsibility as the main factor for the family welfare. The participant has also recalled about his visit to the poorhouse and call for public supports towards abandoned children.

- #P10-EXP – *"I think people should think carefully. Getting pregnant is a serious business because the children will need supports from their parents for at least 15-20 years.*

  I've visited several poorhouses to donate foods and money for abandoned children. Their living groups are not very good. Like, some of them are very skinny and have developed skin diseases. Some children looked very sad although some of them looked happy and cheerful.

... It doesn't necessary mean that these children are helpless because I have heard stories about some abandoned children who went on and become successful in their careers. Some of them have come back to help other abandoned children as well. Maybe harsh life experiences have taught them to be strong, but they are also kind toward others at the same time. I think the society shouldn't reject them and people should donate money to support these poor children ... who knows, some of them could contribute to the society in the future.

<[]> [In order to reduce unplanned pregnancy issue], I think it's a good time for our society to talk about healthy sexual lifestyle openly".

Another participant has recalled about unplanned pregnancy in teenagers. The importance of parental responsibility was discussed by the participant. The participant has suggested sexual education as the solution for unplanned pregnancy in teenagers.

- #P11-EXP – *"... These teenagers are not ready to have children. They are not prepared for such responsibility. Their children will also have problems when they grow up. <[]> Children need a good environment to be successful in their lives. Many of the children have ended up in gangs and crimes or maybe die at young age.*

  <[]> Well, as I've already said, sexual education should be used. We don't have to be shy just tell the fact to the teenagers because the sooner they know the fewer chance they will get pregnant. Teenagers these days know all about pornography, alright? Don't say Thailand is a country with conservative traditions. Many people around the world know about Pattaya and Phatpong district anyway[6]".

Another participant has recalled about large family size in some families living in the rural areas. Interestingly, the concept of children as a form of investment in certain lifestyles has been discussed by the participant.

- #P38-CTRL – *"... But some families like those who live in rural areas might see children as a form of investment. Like, they will need to take care of the children for 6-7 years then the children will be able to help them with farm works. Probably the children will work in the farm for the rest of their lives and help their parents when they get older. So the parents have actually planned ahead to have many children. <[]> I think it depends on circumstances ...".*

3.3 Growing population

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[6] The Pattaya beach and Phatpong district are famous tourist destinations in Thailand. Both areas have gained infamy for their association with prostitution.

A participant has recalled about the growing population issue from the game (starvation and welfare issues specifically). The relationship between consumption rates and natural resources was discussed by the participant. The participant has also discussed the growing population issue in term of social context where the participant's attention appeared to focus on low-income families. The participant's focus on the low-incomes can be linked to the 'scapegoating effect' as highlighted by Centre for Alternative Technology (2010: 155). Also, it should be noted that the participant appeared to focus on the financial capability (as the determining factor for family size) while disregard the environmental impact from the growing population issue.

Contraceptive devices and sexual education have been suggested by the participant as the solution for growing population issue.

- #P11-EXP – *"It's depressing to hear about people dying from starvation. I've seen some photos about malnutrition problems in some countries. The children have to eat rotten foods. I've heard that in some countries the adults have to kill and eat the children because they have nothing to eat.*

  <[]> Well, I think it's about we are having too many people on the planet so we don't have enough food to feed everyone. Just look at wild animals on the TV. When faced with starvation, they just die from starvation. Humans are no different from those animals. However, we humans should care about the welfare of our children so we should reduce the population to match with available resources.

  <[]> … Sometimes I've heard about people criticizing the rich by saying that they are robbing from the poor and I think that's a wrong thinking. Whatever the rich want to do is their own business. They have worked for it after all. They are just lucky that they are successful in their lives. Thus, they should be able to buy whatever their financial capacity allows. They didn't break the law. On the other hand, many poor people I see are having like 4-5 children. Some of the parents are into gambling and drinking … I think that's what made them poor in the first place.

  <[]> [To solve the problem], I think there should be more contraception for sale. Teenagers and adults alike should be provided with sexual education. They should know how to use condoms properly and how to be safe from venereal diseases. The society should be more open to this because if we insist on keeping quiet, these children would get pregnant and then have a lot of children. They have access to the internet anyway so it's not like we can protect them from sexual contents. Actually they don't have to go far because many soap operas also portray sexual contents too".

Another participant has recognized the relationship between growing population, the growing dependent on technological devices (and energy consumption), pollution, and resources consumption.

In linkage to the 'fatalism' stance highlighted above (Centre for Alternative Technology 2010: 153), the participant has noted disease outbreaks as a possible solution for the growing population issue.

Family planning and 'one-child' policy was highlighted by the participant as a possible solution for the growing population issue (although the participant appeared to be skeptical about supports from the public).

- #P21-CTRL – *"I think it's about humans using resources at Earth's top capacity and we are polluting the air and the environment at the same time. <[]> The problem is our lifestyles are becoming more sophisticated and we are polluting the world faster with our current lifestyles.*

  <[]> Say, our ancestors were depended on tools derived from the nature so everything is considered as environmental-friendly. But now people are relying on things like plastic, fuel, … electricity and computers.

  <[]> I think maybe disease is the answer for this problem … Say, some sort of deadly plagues that would wipe out a lot of population like we have seen from zombie movies. On the other hand, we can utilize more peaceful approach like family plans, but I don't think many people are going to listen to that. We can also promote one child family like in China, but again, I doubt if people are going to agree with that. I guess human right groups would be the first to reject that [proposal]. Maybe we have to wait and see … people would be eager to find solutions once the planet gets worst".

Another participant has expressed his disagreement with the growing population issue. The participant's rejection to recognize the issue could be linked to the 'it won't affect me' stance as highlighted by Centre for Alternative Technology (2010: 153). Also, the waiting for the government to take an initiative could be linked to 'others aren't doing enough' stance as highlighted by Centre for Alternative Technology (2010: 156).

The reasons for human procreation have been suggested by the participant. Similar to #P11-EXP, The participant has recognized financial capacity as an important factor determining the family size.

- #P47-EXP – *"I think the fact that the government doesn't control the population is because we still have resources to feed people. I'm aware of disasters like draught, floods, and pollution that can decrease agricultural outputs. However, I think humans will continue to reproduce because that's just the way we are.*

  At least until something bad happened and a lot of people die from starvation then maybe population size will decrease. However, I'm sure that people will soon forget [about the incident] and the same cycle will start all over again.

  <[]> I think it's quite natural that at some points most people will want to have children and there can be many reasons for this. Say, some might want to have children to continue their legacies. Some people say having children can strengthen the bonds between husbands and wives.

  … Point is people can have children as long as they have financial resources and time to do so. <[]> I think it's like everything else in this world, if you have money then you can have whatever you like. So it shouldn't be difficult for a millionaire to have 3-4 children, but it will be very difficult for the poor to have 3-4 children … it will be difficult for their children too".

Another participant has recalled about the growing population issue. The participant appeared to discuss the issue from the social rather than environmental perspective.

In the similar way that population size alone cannot be used as an accurate indicator for environmental degradation (e.g. Vaughan 2009), the participant has reasoned that exemplary members of the public and social values should be promoted for their lawful and moral conducts so that social and environmental problems can be reduced.

- #P67-CTRL – *"I know some people whom I'd encourage them to have many children because they are very good people so they would be able to teach their children the right thing and it's likely that their children will set good examples for people of the next generation.*

  <[]> Say, good persons would oblige to the laws and they won't cause problems. Also, I think good people wouldn't destroy other people or the world for personal profits too.

  <[]> Growing population is the problem, but not the main problem. The main problem is that many people are selfish and corrupted. Too bad many of them are too rich and the law

couldn't touch them. Can't blame people for being selfish, but it's unacceptable for them to take advantages of others".

Another participant has viewed growing population as a location-dependent issue. The participant has referred to the media report – suggesting participant's awareness on the growing population issue prior to the session. Maintaining the balance between population size and resources availability was suggested by the participant as a solution to the growing population issue. However, the external threat from large nations was highlighted by the participant as a point of concern for small nations.

- #P68-CTRL – *"I think the [growing population] problem is restricted to certain locations. For example, I've heard that Japan is encouraging parents to have children because the country is experiencing worker shortage. On the other hand, a lot of people in Africa are experiencing food shortage.*

  <[]> I think it depends on situation in each country. Say, people should match their population with resources availability in the area. However, countries with small population size might feel insecure because they might be attacked by stronger nations".

Another participant has recognized the relationship between limited resources and the growing demands. The concept of choice between efficiency and welfare was raised by the participant as the influential factor for the growing population issue. Family planning has been suggested by the participant as a solution for the growing population issue. Also, an abortion has also been suggested by the participant as a possible last resort to eliminate social problems in the long run.

- #P81-EXP – *"Human population is growing fast, but the world has a finite amount of resources so sooner or later we'll be running out of resources unless we can colonize another planet.*

  <[]> I think it depends on our choices … say, if we remove the seats from the bus then everyone will be standing on the bus which means that the bus will be able to carry more people on board. However, we cannot do that because we are concerned about older population … and pregnant mothers who could not stand on the bus for long. We also care about the children and disabled people.

  Then some people value things like arts and entertainment while others think they are wasteful. Humans are different from the machines so it's not possible for humans to use resources efficiently. People also make irrational mistakes all the time too.

<[]> Again, it depended on our choices … I strongly support family planning because I believe it would improve social group in the country. I have a neutral view about abortion but a part of me thinks it's a terrible thing to do. But again, abortion might be considered as the last resort as we have heard a lot on the news about babies are being flushed down the toilet. <[]> Well if abortion is allowed under certain circumstances then at least we can prevent horrible incidents from happening in the public".

3.3.1 Growing population as a side topic

A participant, while discussing about the design of game theme, has also referred to the growing population issue, limited resources, limited living space, welfare issue, and social security issue. The participant has noted the necessary of population reduction, but admitted that he also want to have a child. In what can be linked to the 'others should lead' stance (Centre for Alternative Technology 2010: 153), the participant has viewed political leaders and scientists as the source of solution.

- #P14-EXP – *"Buildings in the game reminds me of small living space in city areas. It also reminds me about some hotels where people sleep in small cubes. <[]> They look like infant's incubator to me. The world population is growing and everyone is struggling in a fight for living … foods, money, and a place to live.*

  <[]> Land prices are very expensive nowadays. Many city dwellers especially office workers are living in small apartment rooms. Only top managers could afford to buy a luxury condominium. I've seen the living group of some low-income families … they have to make the best use of every inch in their apartment rooms that there's no place to walk around in their rooms. I don't have a big house myself, but I'm lucky to have a small house with a tiny garden and I'm quite happy with that … at least my fate is not at the mercy of some cruel landlords.

  <[]> I think it would be great if we could reduce world population. Everywhere I go is crowded with people. However, that would be a selfish saying because I want to have a child in the future too. <[]> I think scientists and world leaders will come up with the solution when it is time".

Another participant has discussed about the habitat expansion while recalled about the case of encroachment on natural reserves from the reading material.

The constant expansion – supported by the growing infrastructure system was highlighted by the participant. As with #P81-EXP, the concept of choice was highlighted by the participant (creating infrastructure systems for the settlers at the cost of environmental degradation).

Interestingly, the participant has highlighted the 'continuous resources consumption' required for the maintenance of buildings and infrastructure systems. However, the participant appeared to believe that the catastrophic event of resources conflicts might happen in the distant future. This could be attributed to the 'it won't affect me' stance as highlighted by Centre for Alternative Technology (2010: 153).

- #P73-CTRL – *"... Once the new housing projects have expanded into the natural habitat it will be followed by electricity and water. Then business such as shopping malls and commercial offices will follow.*
  I still remember a case where some villagers have constructed wooden houses in the natural reserve then asked the government to provide them with electricity and tap water. <[]> I don't know ... some people might say that we should put the need of people before everything else. <[]> I think we should not agree to their requests and they should be evicted from there because if we allowed it then hundreds of people will do the same thing.

  After that, the small village will start to expand. There'll be road networks and factories. These buildings and infrastructures will require maintenance which also consumes resources.

  <[]> Maybe 500-1,000 years from now people will go back to use horses and do things manually. Or maybe the world would be destroyed by wars caused by the oil crisis. Hopefully I would be long gone by then".

A participant, while recalled about forest conservation issue, has also recognized the relationship between resources, growing population, and health issue.

- #P12-CTRL – *"... Maybe it is because there are too many people on the planet and that's why manufacturers need to come up with things like pesticides and genetically-modified foods to feed millions of people. <[]> Well, I think it helps the situation temporality, but also cause health impacts ... say, low-income people have to relying on cheap foodstuff such as noodle packs in order to meet their ends. These products help them fight off hunger, but will ruin their lives if taken daily".*

Another participant, while discussed about the game in general, has also discussed about the relationship between growing population, resources availability, and the possibility of social disturbance.

- #P39-EXP – *"Human population is growing fast and I think this is the big problem. We're pushing the earth to its limit and pollution problems are looming. It's also getting more expensive for people to buy products. People will be in a chaos once the economy system failed. People who cannot afford enough to eat will do anything to survive including robbing and hurting others".*

Another participant has recalled about a case of deforestation while also noted about the implication between growing population and expansion into the natural habitat. The aspect of efficiency VS well-being was also noted by the participant.

- #P16-CTRL – *"The forests are being destroyed by human activities. Like, the world population is growing and the governments will need to allocate more lands for housing projects.*

  However, these days we have high-rise buildings so a lot of people can live in there. It is efficient, but I think it is unnatural for humans to live in small rooms in high-rise buildings ... somehow I think that [living in high-rise buildings] can be compared to those caged chicken. Maybe this is just for me, but I'd live on the ground-level rather than in high-rise buildings".

Another participant has noted about the growing population issue while discussed on poverty issue. Donation and resources sharing for the poor have been suggested by the participant as the mean to reduce poverty.

- #P56-EXP – *"If the parents produce two children then these two children will produce 2 or more children in the future when they grow up and so forth. But judging people won't make things better because some people are so unfortunate that they don't have enough to eat. I think we should care about millions of people who are starving and don't even have a place to live. I think the problem can be lessened if the rich would just share a little bit of their enormous resources with the poor".*

A participant, while did not participate in the interview fully, has summarized about the declining natural resources, environmental problems, and the increasing resources demands from the growing population. The participant has also highlighted the change in farming and hunting practices that contributed to resources depletion.

- #P51-EXP – *"... But now things have changed, animals have become scarce so you need to farm them and there are lots of thieves trying to steal farmed animals from you. You can no longer drink from rainwater or from the river because of the pollution and you have to be careful when catching animals and insects from the field [for consumption] because farmers nowadays are using high amount of pesticides.*

  <[]> I think there are many issues here. It's obviously about the growing population and so more people that need to be fed. It is also about people are harvesting resources faster than what nature can replenish and it is about changing of lifestyle of people in the countryside like. Many areas now have access to electricity and water. <[]> Like, now people want to get rich fast so they start to use pesticides and selling foods for profits rather than harvest foods for personal consumption".

A participant has referred to the growing population issue while recalled on the disease outbreak issue from the game. In what can be linked to the 'fatalism' stance, disease outbreak was highlighted by the participant as a possible solution for growing population issue. The participant's response also suggested a fatalism stance towards the success of environmental conservation (i.e. 'it's too late').

- #P10-EXP – *"... However, I think diseases also have its use too. It will help the world from being destroyed by human activities when the world is too crowded with people. There could be new diseases that have been developed for warfare. Unlike conventional bombs, diseases only affect target species so the world might be saved that way.*

  <[]> I think all the talk about natural conservation is very hard to accomplish. Nations are racing for supremacy and everyone needs resources in order to live. Without diseases, wars, or some sort of super advanced technology, it's only a matter of time before the world would be destroyed by our hands".

3.4 Food safety issue

A participant has recalled about a case of food contamination from the game. Further, the health benefit from organic food (pesticide-free) and low environmental damage from organic farming have been highlighted by the participant. At the same time, organic food's premium price and limited availability were also noted by the participant as drawbacks.

The large population size was recognized by the participant as the drive for unsustainable farming practices. Soil degradation was also recognized by the participant as the environmental consequence from unsustainable farming practice. The reduction of population size and the use

of advanced technology (i.e. tech-fix) have been suggested by the participant as the solution for food safety issue.

- #P3-EXP – *"I think everyone wants to eat organic foods because they are pesticide-free. However, they are limited in quantity and their price much more expensive when compared to other food products so only the rich would be able to afford them.*

  <[]> But there are millions of people in the world so the slow growth rate of organic food will fail to feed people. So farmers need to use antibiotics and pesticides. But using pesticides also destroy the soil.

  <[]> … [To reduce food contamination problem] I think we need to decrease the population size or inventing an advanced farming technology to increase food outputs".

Another participant has recalled about food contamination from the reading material. The food vendors' responsibility over food safety was highlighted by the participant in the discussion. The law was suggested as a solution to increase food safety standard.

- #P20-CTRL – *"Some food vendors use dangerous chemicals to make food look appealing to the customers …<[]> We need to regulate food vendors by issuing them with licenses. If people report them for hygiene problems then the government can revoke their licenses".*

Another participant has recalled about pesticide contamination in vegetables. Buying food products from credible sources was highlighted by the participant as a possible solution for food safety issue.

- #P79-EXP – *"... I think the best way is to purchase foods from big brands or from the supermarket. <[]> [food safety] cannot be 100% guaranteed, but at least big corporations will protect their brand images and if there's something wrong then it will be on the news and they wouldn't want that."*

Similarly, another participant has recalled about pesticide contamination in vegetables and chemical contamination in seafood. The participant has suggested that it is impossible to archive total food safety standard due to negligence from food producers / harvesters. For this, growing food for personal consumption was suggested by the participant as a solution.

- #P8-CTRL – *"... Vegetables and fruits are sprayed with pesticides. Also, fishermen use formalin to keep the fish in good appearance and the government cannot inspect every load from hundreds of ships so it's impossible to guarantee food safety. As consumers, our lives seem to rest with the responsibility of food producers who barely care for the consumers.*

<[]> The only solution would be to become a farmer and grow the food and vegetables by ourselves. That way, we can ensure the 100% food safety".

Another participant has recalled about food safety in food processing industry. The participant has suggested reporting irresponsible food providers using social media as the solution to maintain food safety issues.

The participant has also discussed about the illegal online distributions of medicines and supplementary tablets. The participant has suggested the law enforcement as a solution to the problem. Also, the participant has criticized consumers for their carelessness.

- #P40-EXP – *"... The internet can be used to share information about food safety. Sometime people would post on the internet and the news spread quickly. <[]> There was a case where someone ... presumably a restaurant staff posted a video clip about the unhygienic kitchen which led to the closure of the restaurant.*

  Also some people have bought medicine and supplementary tablets online from untrustworthy sources. There have been a number of incidents where consumers have experienced adverse side effects or even resulted in death yet many people continue to believe the advertisement and use it.

  <[]> The government should prosecute the distributors. They should be put in the jail for a long time for many lives they have ruined. But seriously, most of the buyers are no longer children so they should be able to think for themselves too".

3.5 War

A participant has referred to the media report on armed conflicts and war. The welfare issues of war refugees have been discussed by the participant.

- #P1-EXP – *"War is the worst social problem because people suffer greatly from war. I saw the report about recent wars and it's terrifying because refugees have to live in small tents. There will be problem with eating and sanitary issues. Security must be very bad because tents are not made to withstand crimes and crimes must be problematic over there because refugees will be fighting each other for resources.*

Another participant has noted about the terror of weapons used in warfare.

- #P28-CTRL – *"I've seen photos of children who have been affected by chemical and flame weaponry. It must be very bad. Some prisoners were beheaded too".*

Interestingly, another participant has also recognized about environmental impacts caused by advanced warfare.

- #P49-CTRL – *"I think war, along with environmental problems will bring about the end of humanity. In ancient times, people would just use swords and spears for fighting, but today's wars involve the use of hazardous weapons such as bombs and rockets so we are causing damage to the natural environment as we fight among ourselves".*

Another participant has noted about the loss of lives and resources used in warfare. The participant has suggested peaceful cooperation between global nations in order to consolidate security resources on maintaining internal security.

- #P56-EXP – *"... A lot of people especially the innocent will be killed and a lot of resources will be wasted. If nations can stop waging wars then maybe the military can help police force on internal security to reduce crime level. For example, the army's engineering corps could be used to repair buildings and roads instead of making bombs".*

4. Top 5 technological topics

4.1 Smart products

A participant has recalled about the concept of real-time metering system[7]. The participant has recognized the benefit of real-time feedback provided and suggested technological integration (link up with mobile phones). Interestingly, the participant has suggested that the device could be used to clarify disputes in the billing systems. The environmental benefits from resources conservation, however, was absent from the discussion.

- #P13-EXP – *"... I think it will be useful because we would be able to monitor our usage all the time. Apart from that it would eliminate the error in billing system too. The government would sometimes make wrong calculations and charged people very high for electricity and water. I've heard about some people who had been charged like [£500] for electricity and water only for the government to realize later that there was a glitch in their computer system.*

  Maybe in the future [the smart meter] could be linked with mobile phones for remote access".

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[7] A device that provides feedback on energy and water consumption to users in real-time to promote resources awareness and possibly reduce users' energy and water consumption.

Another participant has recalled about the concept of sustainable packaging from the game. Interestingly, the participant has referred to the use of banana leaves as natural food packaging material (not included in the leaning mediums). The participant has also referred to the concept of 'sustainable shopping' from the game (e.g. filling emptied packages with new content in order to reduce packaging waste).

- #P14-EXP – *"It makes me think about how banana leaves were used as plates or packing foods in the past … not really a new technology though. <[]> Unlike foam containers they can be used to hold hot food and they are biodegradable. Now look this way, I think much of [non-degradable] wastes have been used in food packaging.*

  <[]> … Similarly, supermarket can allow customers to refill their empty containers with new contents. I think there are many products that can use this strategy. Say, household chemical products, egg containers, and ready-to-go meals. However, I think some products like tin cans and alcoholic beverages cannot be refilled this way because they require special sealing techniques.

  <[]> We can use discounts to encourage customers to reuse the containers. <[]> This might not be a huge profits for the business, but at least it could boost their images on environmental commitments".

Another participant has recalled about the concept of waterless toilet from the game. The key benefits (water conservation & gas production) were noted by the participant. The participant's desire to invest in the system appeared to be based on the long-term financial benefits. Also, the participant has recalled about his real-life encounter with 'thin-filmed water bottle' – another smart product attempts to reduce plastic material used in single-use products (this product was not highlighted in the game).

- #P30-EXP – *"the idea of waterless toilet is really cool. I've heard about water-saving toilets before, but I've never imagine that one day someone would come up with the idea of waterless toilets. Plus, I really like the idea that they can convert toilet waste to gas for useful purposes. It sounds like a win-win investment to me. I hope the system is reliable and hope someone would import these toilets to our country soon. <[]> I want to buy it if the system is reliable. <[]> I don't think price is the major problem since this thing will pay for itself in the near future*

  … Also, I've read labels of some bottled water and they said something like 'this bottle uses 20-40% less plastic'. I think that's a very innovative".

Another participant has recalled about the concept of 'replaceable toothbrush bristles'[8] from the reading material. Also, the 'tube squeezer'[9] was described by the participant as another innovative sustainable product.

Interestingly, the participant has also highlighted about social stigma against resources-conscious consumers.

- #P37-CTRL – *"I remember my brother brought a toothbrush like that from the hotel aboard. <[]> It can be separated into two parts, but I don't think it was meant to be replaced because it was just a cheap hotel toothbrush … perhaps it was meant for easy transport. However, imagine if we adopt that design and use it for commercial toothbrushes. The large amount of plastic waste could be reduced that way.*

  Also, some people use tube squeezers to extract the remaining toothpaste left in the tube. <[]> I don't have [a tube squeezer] at home, but my dad would cut the toothpaste container in half so he can use all remaining toothpaste left in the tube. That's more efficient than using tube squeezer, but I think people in this generation no longer [cut the toothpaste tube] <[]>… maybe people don't want to be seen as a miser?"

Another participant has recalled the concept of 'advanced battery' (high-performance, environmental-friendly battery) from the reading material. In participant's perspective, product replacement may not be an ideal business practice due to the lack of profits. Industrial standard and product compatibility have been suggested by the participant as a pathway towards the concept of smart products.

- #P57-CTRL – *"I like the concept of environmental-friendly batteries because conventional batteries are quite harmful without proper disposal. <[]> I'd buy [environmental-friendly batteries] as long as they perform similarly to conventional batteries and the price is not exaggerated.*

  … I don't think it would be very profitable for businesses to make spare parts since you can make more money by selling the new unit and creating new products. But it would be great if [manufacturers] would think about environmental reputation because it can boost their companies' images as well. Many corporations are using sustainability as a part of their marketing strategy.

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[8] Replacing the 'head' part of a toothbrush while retaining the stick in order to reduce plastic and rubber waste.

[9] A small tool uses to help squeeze the content from toothpaste and cooking sauces – reducing resources waste.

Take computer mice for example, me and my colleagues throw away a number of computer mice every year because of broken mice cords and sensors. Now what if we can just bought spare parts so that we don't have to throw the entire unit away? Besides, I tend to stick with the same type of mouse for so many years. I think the same should go for printers, telephones, and mobile phones.

Also, the industry should create a universal standard for electronic devices so one device can use the same power cord type with others ...".

Another participant has recalled on the concept of 'smart elevator'[10] from the reading material. The participant appeared to discuss the dialogue from financial rather than environmental perspective. According to the participant, financial charges can be used as a form of negative reinforcement to prevent overuse and promote energy awareness.

- #P43-CTRL – *"My apartment charges tenants relatively high for the central electrical consumption. <[]> Elevators are the most energy-consuming appliance in my apartment according to the bill. I think many people are over-using the elevators.*

  <[]> I've paid for the central electrical consumption like [£6] last month and I've only used the elevator for only twice because I was mostly away from the apartment that month. <[]> Exactly, [that was unfair] ... I once saw three kids using the elevator to go up and down. They were playing with elevators. And not to mention that kids shouldn't be allowed to use elevators alone in the first place.

  So this [smart elevator] system sounds like a fair deal to me. <[]> Like, if you need to use elevators often then you'll need to pay more which makes perfect sense. With this system, many people will think twice before using elevators. I think what's more interesting about this [smart elevator] idea is the message that we're sending out, you know? Like, we send out the message to occupants that electricity is not cheap".

4.2 Solar technology

A participant has noted the high-price of solar panels as an obstacle for the deployment. However, the participant has a positive view on technological development of solar technology. The aspect of land use has been highlighted by the participant. In what can be linked to the 'other

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[10] Smart elevator is a concept of using pre-paid tokens to charge elevator users according to their usage to discourage overuse. Elders and physically handicapped users receive service discount.

should lead' stance (Centre for Alternative Technology 2010: 155), the participant has suggested that wealthy individuals should take the lead in utilizing the solar technology.

- #P2-CTRL – *"I think solar panels have been around for many years but the problem is that it's too expensive and people cannot afford them. However, since we now have the technology to make solar panels cheaper then I think people would want to have one on their roof. I've been to the countryside and I see a lot of desolated lands receiving plenty of sunlight so I think the government or investors should put the panels there so they could generate extra income from the empty land.*

  <[]> I really want [to install solar panels] because the area I live in has received a lot of solar energy ... well, I guess it's all the same everywhere as our country has plenty of solar capacity. Again, the problem is price. Maybe I watch rich people use [solar panels] first and if it's good then I'll follow".

Another participant has recalled about the concept of industrial-scale solar cookers from the reading material. Both the environmental and financial benefits from using solar energy have been recognized by the participant. However, several limitations of solar cookers have been noted (inconvenience and meteorological interference). Price appeared to be the main factor for the participant when consider investing in the solar technology.

- #P4-CTRL – *"I think we might be able to reduce a lot of gas bill by using this device. I like the idea that the industry can use [the concentrated sunlight] as energy source too. If we could improve this technology further then it would help reduce pollution problem and fuel consumption. <[]> I think the problem [with solar cooker] is that people need to move their kitchen unit out in the garden [to receive the solar ray].*

  We won't be able to use it when there is no sunlight. Maybe you have already cooked the food half-way, but have to bring the food back inside when it starts to rain. However, I think the device would be useful during summer season. It might make the food taste delicious because it was cooked from the clean solar energy. <[]> I'd like to buy one if it is not too expensive".

Another participant has discussed from his personal experience about the low-durability of the solar panels. The participant has expressed his desire to invest in solar panels, although appeared to be deterred from his experience with low-durability solar panels. The participant has also highlighted an issue with a government-funded solar panel program.

- #P43-CTRL – *"I've bought a solar lamp from the shop couple of years ago. Then it ceased to work soon after the warranty has expired. So I went back to the shop, but they said the repair cost would outweigh that of the lamp itself. On the other hand, my solar-powered calculator is very old, but still working to this day and I couldn't understand exactly what happened with that lamp. New technologies are supposed to be better than the old ones.*

  <[]> Maybe when the technology is better I would be able to save enough money, go back to my hometown, and install solar panels in our lands and sell the energy to neighbors ... or probably just put small panels on the roof to see the benefit first.

  <[]> ... Talking about the support on solar projects, I've heard a problem some years ago that the government had issued free solar panels to a remote village so villagers could use electric lamps in their house at night instead of using oil lamps. However, at some point afterward many villagers have sold their [give-away] solar panels in order to gain fast cash. <[]> I think if those villagers no longer wanted the solar panels then they should return it to the government because those solar panels were given to them for free ... they were essentially the government's assets after all".

Another participant has recognized the dwindling non-renewable resources and suggested solar energy as an alternative, environmental-friendly energy source. The Return of Investment (ROI) aspect was the main concern for the participant when asked about installing solar panels. In what can be linked to the 'other should lead' stance (Centre for Alternative Technology 2010: 155), the participant has suggested that the government should lead the solar energy program. The remote area was suggested by the participant as suitable location for solar panel farms due to the perceived lower land value.

- #P49-CTRL – *"I think solar technology will be a suitable energy source for our country. Oil is depleting and I think oil price will be very expensive in the future. On the other hand, solar energy is unlimited and clean.*

  <[]> For a very long time, I've always wanted to install solar panels on my roof, but I want to make sure that it'll be a good investment ... Solar panels are quite expensive at the moment.

  On the other hand, the government should pioneer the project so others can see the benefit of installing solar panels. Maybe they could install solar panels at government buildings and remote areas since the lands value are not as high as in the city. Besides, I'm guessing that it shouldn't be very difficult to relocate solar panels to other areas if needed".

Another participant has a positive opinion about solar panels based on the country advantage in high solar capacity and the advancement in solar technology. Efficient land usage (rooftop installation) was noted by the participant as another reason for installing solar energy. Similar to #P49-CTRL, the participant has suggested that the government should play a leading role to encourage the installation of solar panels.

The participant has expressed his interest in solar technology, but also highlighted that the confidence in solar panels' reliability and additional knowledge is required before the investing in solar panels.

- #P51-EXP – *"I think it's a very good technology consider our country is hot and has plenty of sunshine. It's good to see that the technology is getting better now. So it should be a good investment for everyone because most of us don't use the roof to do anything anyway. <[]> I think the government should encourage the use of solar panels. We could use experts who could give suggestions to us like where to buy the solar panels as well as tips and tricks.*

  <[]> [I would buy solar panels] if the technology is good. It would be a waste of money if I bought it and it break down in just few years".

The same participant has also recalled about solar cooker technology from the game. The participant appeared to have a higher positive opinion towards solar cooker technology than that of the solar panels. The participant's reasons may have stemmed from his familiarity with the concept of solar concentration device (i.e. magnifier used to concentrate the sunlight) and / or the perceived 'easy-to-use' aspect of the solar cooker device. Although price appeared to be the key factor, the participant has expressed his desire to invest in the solar cooker device.

- #P51-EXP – *"I think it is a great idea that people have overlooked. I've used a magnifier to concentrate the sun and burn some leaves before, but haven't thought that it could be developed into something big.*

  <[]> I'd love to have one at home. It sounds like a straightforward technology unlike the complicated solar panels. Maybe I can use it for cooking or boiling hot water for the shower. If I can find it and it's not too expensive then I will definitely buying it".

Another participant has discussed on technological advancement of the solar panels. The participant has expressed his desire to install solar panels, but cited high-price and the lack of information as the main factors preventing him from doing so.

- #P61-EXP – *"From what I've read, I think solar technology is progressing well and would become affordable by the public soon. <[]> I'd like to install solar panels at home, but the problem is the price is still high. Further, I don't know what system I should buy and I don't know if there's anything else I should know before setting it up.*

  If it's only the matter of putting the panels on the roof to receive the sunray, then I would want these panels when the price is affordable".

Another participant has envisioned the design of solar panel system. When asked about investing with solar technology, the participant has noted the high price as an obstacle for installing solar panels.

- #P76-EXP – *"... I would like the engineers to one day, design solar panels that could be expanded or folded like an umbrella. This way, people can decide whether they want the sunlight to reach the ground or not.*

  <[]> Solar panels' price is still high at the moment. I would wait a little bit more for the price to become lowered".

Another participant has noted about environmental and financial benefits from using solar cooker and solar panels. Again, the high price appeared to be an obstacle for installing solar panels.

- #P77-EXP – *"Cooking foods with sun power sounds nice. <[]> We can save the fuel cost and the environment at the same time. Also, we can use solar panels to produce electricity too.*

  <[]> Well, I've heard that electricity generated from solar panels is still very expensive when compared to electricity generated from other sources. <[]> I just want to make sure that the technology is good and reliable before putting my money on it".

Interestingly, another participant has discussed about the use of solar panels and solar cooker in business context. Although with limited knowledge, the participant appeared to be interested in investing in solar technology.

- #P21-CTRL – *"I want to use solar panels and solar cookers to reduce the energy bill in my apartment complex. We have got plenty of [solar capacity] on almost every day. <[]> I could say to my customers that we cooked our food with the sun energy and that might be an interesting marketing strategy.*

<[]> I think some foreign customers are very concerned about environmental protection. <[]> They will feel happy knowing that their hosts are committed to environmental protection. Sometimes they would pay more for that too.

<[]> I'm willing to use solar cookers. However, I'll need engineers to make recommendations on solar panels. <[]> I'm aware that solar panels are quite expensive at the moment, but we can start with a small one and use it for lighting. After that we could have a look at the new technology and expand the use of solar panels accordingly".

Another participant has expressed his interest in solar panel technology, but citing price, low energy yield, and portability as the reasons preventing him from using the technology.

- #P5-EXP – *"I like the concept of solar panels. <[]> I used to think that it would be easy to reduce our gas and electrical consumption by putting solar panels up on the roof, but my brother protested against the idea because solar panels are expensive and [the energy produced] won't be enough to satisfy our needs.*

  Further, we are constantly on the move. We don't know for how long are we going to stay at our current house and it would be costly to dismantle and transport solar panels with us to the new house".

4.3 Robotic technology

A participant has recalled about the concept of 'robotic workforce' from the game (advanced robots that can be programmed to work in various tasks). Convenience, reduced operational cost, and increased productivity have been noted by the participant as the benefits from utilizing robotic technology.

- #P1-EXP – *"I've watched a movie and I think it would be great if we can use robots to do jobs for us. <[]> Well, like in the movie where robots can be used to clean the street and work in the factory.*

  It will be good in the long run because you don't have to pay for the workers. You don't have to pay for insurance, medical bill, and you don't have to worry about people quitting their jobs. Productivity can also be increased because they can be put to work 24 hours a day without violating the labor law".

Similarly, another participant has recalled to the concept of 'robotic workforce' from the game. The participant has discussed robotic workforce technology from agricultural perspective. Skilled labors and labor shortage was noted by the participant as the key issue for agricultural business.

The participant has referred to the advanced farming robots in the real-world. High price has been suggested as the main obstacle preventing the use of robotic technology.

Also, the security concern in farm operation has been highlighted by the participant. In participant's perspective, robots could be used in place of guard animals to increase reliability in farm security and decrease operational costs in the long run.

- #P30-EXP – *"My relatives operate a small farm and I think the concept of automated farming is very interesting because farm operations are largely depended on labor workforce. My uncles are very experienced in farming operation, but they are getting old and cannot perform the hard work like before. Good farm hands are hard to come by. <[]> I think Thai people would rather work as office clerks rather than in farms. Thus, our farm is relying on foreign workforce from neighboring countries and most of them won't be staying with us for long.*

  <[]> There are some equipment that we are using such as combined harvesters and animal feed mixer, but these equipment require skills. Actually, I've seen some advanced agriculture robots on the internet, they are very smart but the prices are also prohibitively expensive.

  Also, another threat to farm operation is thievery. It would help a lot if robots could be used to patrol the farm all day long. <[]> We are using dogs to guard the farm, but some dogs have ended up being kidnapped by thieves. It's almost like 1-2 dogs would be killed or kidnapped every month. Besides, we love dogs and I cannot bear to abandon them when they are sick or old. So we take a great care of them, but that is also expensive and time-consuming".

A participant has recalled about the concept of robotic spiders (small-sized robots programmed to seek and eliminate agricultural pests – an alternative to toxic pesticides).

While recognized the long-term financial and environmental benefits from using the technology, the perceived high-price was note by the participant as the main drawback. Support from the government was suggested by the participant as an important factor for development and deployment of sustainable technologies.

- #P68-CTRL – *"It sounds interesting. <[]> They are not real spiders, but they can kill small animals like the real spiders. Besides, they don't need to be fed with live pray.*

  However, robots might be too expensive for ordinary farmers. <[]> Maybe the government could sponsor the project. I mean we have engineers on competitions to build football

playing robots so why don't we put our efforts into something useful like this? We are one of the world's top producers in agricultural products so our country will benefit from using them. Imagine we use these robots to combat agricultural pests ... the farmers will be less depended on pesticides. Besides, we would be able to preserve the land because intensive use of pesticides will destroy the soil".

The same participant has also recalled from the reading material about using technology to increase seafood harvest rate. The benefit of convenience was highlighted by the participant. On the other hand, the aspects of energy consumption and resources depletion caused by accelerated hunting have been recognized by the participant as the drawback.

- #P68-CTRL – *"I like the idea that an inventor has used his submarine to assist in the harvest of seafood. <[]> I think using robots to harvest crops and farmed animals automatically is a very good idea. Working in the farm can be a demanding task.*

  However, we must be careful here because machines require energy ... unless those machines can be powered by the clean energy. Also, if used to harvest products from natural habitats, machines will speed up the harvest process which can lead to animal extinction as well".

Another participant, while did not complete the interview section fully, has discussed about the use of robotic technology for forest protection. In participant's statement, the value of the natural environment (tree) has outweighed the cost of security robots used in natural protection.

- #P59-EXP – *"... Besides, we can use robots to help protect the forest. I mean what if we place sensors in the forest so it can alert forest protection officers when someone tries to cut down the trees? And robots too ... I think we could use remote-controlled planes to patrol the forest. I think it will be faster than human patrols too.*

  <[]> Although the cost of the robot is expensive, I think it would still be cheaper when compared to the loss of forests. I've heard that just several logs from rare woods could worth like [£500-1,000] in the black market".

Another participant has recalled about the concept of crime prevention robots from the reading material. The use of CCTV / internet for remote monitoring was also suggested by the participant as another use of crime prevention technology.

- #P42-CTRL – *"It sounds like the idea of Robocop is getting close to reality now. Maybe we could put CCTV in buildings and let disable officers monitor crime activities too. <[]> Many CCTV nowadays can transmit information to another location via the internet".*

4.4 Sustainable farming technology

A participant has suggested money saving, pesticide-free products, and environmental benefit as the advantage of backyard farming. However, the lack of free space was cited by the participant as the reason for not doing backyard farming.

- #P2-CTRL – *"I think it's a good idea because people can grow their own vegetables for free and without pesticides ... and we won't be making waste from packaging too. <[]> [I'm not planning to start backyard farming because] I don't have free space at home".*

Similarly, another participant has cited limited space as the reason for not doing backyard farming. However, the participant has suggested unused lands as possible locations for urban farming.

- #P13-EXP – *" I've read about tending gardens will make one more concerned about the environment ... not far from my place is an empty plot of land and it has been abandoned for many years now. Imagine if someone can actually plant some seeds to grow vegetables.*

  <[]> I don't think the venture would make big money, but it is sad that the land has been left like that for many years now without anyone doing something productive about it".

Another participant has recognized health benefits from consuming vegetables from backyard farming. Time appeared to be an obstacle preventing the participant from practicing backyard farming. The participant has also recalled about the game concept of 'earthworm farming' in term of financial benefit that could be gained from raising earthworms.

- #P47-EXP – *"Growing your own vegetables is a good idea considers that farmers are spraying pesticides on vegetables and fruits to extend shelf life. <[]> I used to grow chili and basil, but I've lost them to the flood last year. <[]> I'm not sure if I want to do it again this year because I'm too busy right now.*

  ... I find the concept of earthworm farm interesting. <[]> From what I know, earthworms are good for the soil. They can be fed with vegetable leftovers so feeding them shouldn't be a problem.

<[]> I'm scare to touch [earthworms], but people could try to raise them for an extra income by selling them to anglers".

Another participant has recalled about the game concept of assigning prisoners to farm organic vegetables. However, the issue appeared to be emphasized on the social context rather than environmental or health benefits offered by organic farming practice. The participant has also suggested assigning prisoners to other public works.

- #P39-EXP – *"I think it's a good idea to have prisoners to work in the field so at least they are doing something useful rather than just sitting in their cells all day. Every prison in the country should do that. Then we can sell organic vegetables and fruits to the public in the same way that the prisons promote handmade furniture crafted by prisoners.*

  … Farming is not a hard job though. I know a lot of people in their 50s still doing farm works so it can't be too hard for these people. Besides, I don't think we should limit them to farming. How about putting them to work cleaning the park and other public spaces? With technology, we can put devices to keep track on them and if they try to escape then we increase the jail time for them too".

Another participant has recalled about the concept of 'alternate feed'[11] from the game.

The participant then referred to the concept of using chicken feces as feeding material for farmed fish. The benefit of operational cost reduction from using the technique has been noted by the participant.

However, the participant's statement appeared to be incomplete as the aim of the original concept was not feeding chicken feces to the fish directly, but to use chicken feces to create maggots which then can be used as protein source for the fish.

- #P56-EXP – *"… It reminds me of the king's project where he has pioneered farmers to raise the fish underneath chicken farms. So chicken's feces could be fed to the fish and reduce the operational cost in the process".*

4.5 Food processing & preservation technology

A participant has referred to the concept of the 'food storage complex' from the game. The participant has referred to the use of freezing (food preservation) in the real-life where food can be stored for an extended period of time. When asked, the participant has reasoned that the cost

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[11] This is the concept of using animal feces to breed maggots, which then, can be used as live feeds for farm animals such as fish and frogs. Another study uses animal feces to raise planktons in the pond, which then consumed by the fish (Argitech 2013).

of food waste would outweigh the electrical cost used by the freezer. To this, the participant has demonstrated energy conservation awareness by suggested a strategy to reduce electrical consumption of the freezer (refrain from open freezer door).

- #P47-EXP – *"One can store meat and fish in the freezer for more than 5 months and they can still be eaten with no adverse health effect. However, the texture and the taste would chance. <[]> It's true [that freezer storage incurs additional electrical cost], but that electrical cost is still cheaper than the cost of food waste. Besides, electrical cost can be minimized by provided that one doesn't open the freezer's door often".*

Another participant has noted the use of non-toxic method for pest elimination. The participant has also referred to the media report to emphasize the importance of systematic food storage environment. Further, the participant has made a link between food waste and starvation issue.

- #P73-CTRL – *"Food preservation technology is very important. <[]> Like, the idea of using radio waves to kill insects because it sounds like an environmental-friendly technology. However, food storage system is important too. <[]> Like, if we have a secured storage warehouse then the rice can be safely stored from humidity and rats. We've lost a large amount of rice during a major flood disaster few years ago due to a poor storage facility. It was a pity because we could have used that rice for disaster reliefs or given to animal shelters.*

    It is very strange that millions of people are suffering from starvation while enormous amount of foods are being wasted at the same time".

Another participant has recalled about the concept of meat extractor from the game. The participant appeared to favor the use of robots in food processing industry (i.e. tech-fix) – citing robots' greater level of safety and speed when compared to human workers.

- #P51-EXP – *"I think the concept of meat extractor is possible in the near future consider that robots can do many wondrous things nowadays. <[]> A factory requires hundreds of skilled labors and no matter how skillful they are, they are still prone to errors and their speed can never exceed that of the machines.*

    Also, speed can let to accidents. I've heard a lot about workers who have lost their arms or lives while working in the factories. So computers and robots could be used in place of humans in dangerous working environment".

Similarly, another participant has recalled about the concept of meat extractor from the game. The participant appeared to favor the use of robots by citing food safety issue as a reason.

The participant has also referred to a report which appeared to be about the 'In vitro meat' (the concept of 'In vitro meat' was not included in the game). Financial and ethical benefits from utilizing In vitro meat technology have been highlighted by the participant. However, due to its unnatural origin, the participant has expressed his uncertainty about consuming the meat produced by this technology. The participant has highlighted the usefulness of the technology to sustain the growing food demand from the growing population.

- #P30-EXP – *"Using robots could ensure food safety for the consumer. <[]> Some factory workers just won't care about the safety of consumers. Sometime consumers would find unexpected items in their food.*

  Another thing … I've heard about scientists have reported that they are getting close to making the machine that could cultivate meat from a growing medium so people could grow food from home. <[]> It sounds like something from the sci-fi movie. Perhaps [using this technology] will save animal lives. Perhaps the meat of expensive animals could be produced this way at affordable cost. <[]> I don't know [if I want to eat the meat produced this way or not]. It sounds very unnatural to me, but one day it might be a common household technology because the world population will be too demanding for the conventional farming operation".

Appendix 11: The list of questions

The following is the list of 23 questions used in the pre- and post-test. As mentioned elsewhere, 19 are multiple choices questions and 4 are true-false statement questions. Options marked in dark blue represent the correct answers.

Q1. What is the approximate projection of global human population in 2014?

☐ 9 billion ■ 7 billion ☐ 5 billion ☐ 3 billion

Q2. Which region has the most malnutrition and hunger rate?

■ Asia & Pacific ☐ Africa ☐ Latin America & Caribbean ☐ Europe

Q3. Which sector is the most responsible for the majority of Nitrous Oxide emission?

☐ Industry ■ Agriculture ☐ Household ☐ Military sector

Q4. Which farmed animal species is the top contributor of methane emission?

■ Cows ☐ Sheep ☐ Chicken ☐ Fish

Q5. Which statement is correct?

☐ 34.2% of energy production in Thailand came from renewable sources

☐ Renewable energy technologies contribute no environmental impacts during their lifetime

☐ All is correct

■ None is correct

Q6. What is the main cause for unplanned pregnancies in Thailand?

■ Lack of knowledge on how to use contraceptive devices properly

☐ Lack of access to contraceptive devices

☐ Lack of money to purchase contraceptive devices

☐ None is correct

Q7. Which one is an average life expectancy for solar cells (for acceptable performance)?

☐ 5 years ■ 20 years ☐ 60 years ☐ 100 years

Q8. What is the main issue for wind and solar energy?

☑ Intermittency in energy production ☐ Maintenance issue

☐ Lack of skilled workers to operate the system ☐ Interference with radio frequency

Q9. Which gas is mainly produced during the process of Anaerobic Digestion (AD)?

☑ Methane ☐ Oxygen ☐ Zethane ☐ Argon

Q10. Which statement is correct?

☐ About 6.1% of global energy is used to convert nitrogen to ammonia

☑ Rice paddies generate and release emissions to the atmosphere

☐ About 70% of agricultural production worldwide has failed to reach consumers

☐ None is correct

Q11. Which one is the correct projection of Thai's forest land in 2013?

☐ 82.11% of total land territory ☐ 70.51% of total land territory

☐ 51.28% of total land territory ☑ 33.80% of total land territory

Q12. According to a 2012 WHO report, which pollution type is the world's most serious environmental health risk?

☑ Air Pollution ☐ Water Pollution ☐ Soil and Food contamination ☐ Radiation

Q13. Which one is the correct melt projection of Greenland and West Antarctic ice sheets?

☐ Sea level will be raised by about 0.5 metres ☐ Sea level will be raised by about 2 metres

☑ Sea level will be raised by about 7 metres ☐ Sea level will be raised by about 11 metres

Q14. Which one is the main source of environmental problem?

☐ Global warming ☑ Resources extraction

☐ Conflicts and Wars ☐ The shifting of earth's magnetic fields

Q15. The majority of global electrical generation is now produced from …

☐ Nuclear power ☐ Hydro & wave power ☑ Coal & Natural gas ☐ Solar energy

Q16. Which one is the annual death rate of children under age of five caused by malnutrition?

☐ 0.3 million   ☐ 1.08 million   ☐ 2.4 million   ☑ 3.3 million

Q17. Which statement is the most accurate?

☐ Less than 4% of global freshwater is available for human consumption

☐ Less than 3% of global freshwater is available for human consumption

☐ Less than 2% of global freshwater is available for human consumption

☑ Less than 1% of global freshwater is available for human consumption

Q18. Which statement is INCORRECT?

☑ 15.4% of freshwater is being used for agriculture globally

☐ About 3.4 million people died each year from water-related diseases

☐ About 780 million people worldwide do not have access to clean water

☐ None of the above

Q19. In order to support rapid population growth, FAO predicts that food production needs to be increased by?

☐ 10% by 2050   ☐ 30% by 2050

☑ 60% by 2050   ☐ 100% by 2050

Q20. We get one kilogram of meat for every two kilograms of grass fed to the cow

☐ True   ☑ False

Q21. Climate change increases rates and magnitudes of natural disasters

☑ True   ☐ False

Q22. Large quantity of antibiotics are being used in farmed animals

☑ True   ☐ False

Q23. Two males and two females of the same species are sufficient to prevent the said species from extinction

☐ True   ☑ False

Appendix 12: Future works on THE GROWTH

This section discusses the planned conceptual frameworks for the next iteration of THE GROWTH. Based on participants' comments and the cut content (due to time restriction on the development phase), new mechanisms will be implemented to promote an engaging learning environment as well as highlight environmental, financial, and social associations to the players in greater details.

New GUIs (Graphical-User-Interface) will be added and the game will support the use of hotkeys for easy navigation / command issuing within the game. Following participants' reception, the choice of graphical representation will shift from 3D to 2.5D environment. This change will allow the game to be operated on lower grade computer systems while retaining robust graphical representation.

1. Timeline & Change in consumption patterns

Table: Example of a conceptual framework on timeline & change in consumption patterns. Environmental degradation will be magnified as the game progresses. In addition, larger population size will accelerate the process of environmental degradation faster than smaller population size.

Timeline	Population	Env. degradation modifier	Accelerated env. degradation rate (%)
2020	1,000,000	30 pts. / sec	0%
2030	1,000,000	33 pts. / sec	3%
2020	1,500,000	50 pts. / sec	0%
2030	1,500,000	55 pts. / sec	5%

As mention earlier, literatures have suggested that global consumption will be increased via changes in lifestyle and consumption patterns – accelerating the process of environmental degradation (e.g. increase demands for energy consumption, meat-based products, and electronic products).

To this, a software script can be used to simulate the change in consumption pattern over time. For example, base environmental degradation rate will increase by 10% after two hours into the game then continues to rise at each interval to the maximum of 70%. This increase will also be in relation to the amount of population presented in the region (see a figure above).

However, this simulated change in consumption patterns requires that meaningful environmental protection policies and sustainable technologies of the future should also be presented to highlight innovative measures that could be used to mitigate environmental problems of the future.

2. A shift from 3D to 2.5D Environment

Based on participants' comments on visual presentation, the next iteration of THE GROWTH will shift from 3D to 2.5D graphical representation. As mentioned earlier in GEG chapter, 2.5D game objects can be used to deliver an illusion of three-dimensional objects while requires less-powerful computer system to operate at the same time. This implies that: 1) the game could be distributed to wider population, especially in developing regions where access to high-end computer systems is limited and 2) Detailed artworks can be created without imposing significant performance pressures on low and medium-end computer systems.

3. Expanded interaction with in-game objects

The current version of THE GROWTH sees limited interaction between players and game objects (i.e. buildings in the game scene). Based on players' comments on this limitation, the next iteration will see direct interactions between players and game objects. For example, selecting a game object will give basic information about the selected game object (e.g. building description, occupants' density, amount of energy / water consumption, amount of pollution generated, and building condition). Further, additional options and information feedback system such as 'read more' (full information/story about the selected object), 'take over' (i.e. purchase the building), and 'upgrade' (i.e. building improvements) can be accessed by players directly via selecting objects from the game scene.

Several random events will be integrated into game objects. For example, A GUI will alert players of crimes in the region. Selecting this GUI will move the game camera to the location of a building being attack by criminals. Provided that players have already invested in a 'private security company', players can dispatch crime prevention units to the scene within certain time limits (e.g. within 10 seconds), If successful, players will have a 20% chance to gain 1 influence point (see influence factor section).

4. Partial refunds for the failed upgrades and investments

Following few participants' comments on the current game version where players would lose 100% of resources if the upgrade / investment have failed, the new mechanism will levitate this penalty where players will lost only a portion of resources in case of failures. This loss will vary depend on the type of upgrades and investments. For example, players will lose 30% of resources initially invested into a failed 'recycling campaign', but will lose 80% in a failed 'advanced battery'

experiment (assuming that the majority of precious metal and other resources have already been used in the battery research).

On the other hand, players will lose 20-50% of initial resources put into investment options depending on the type of business.

5. Building transformation

The new iteration will introduce a new feature where players can transform existing human habitats into sustainable environmental and social projects. For example, players will have options to transform housing areas that they have previously acquired (via investment option) into: 1) an advanced high-rise accommodation 2) a vertical farm 3) a compressed air energy storage park. The proposal of transformation may fail (due to rejection from current occupants), causing players to lost 10-30% of initial investment resources in the process.

6. Non-expansion pact

Non-expansion pact is a planned game mechanism for the next iteration and can be considered as the ultimate goal of THE GROWTH. As outlined in game story, human habitats have already expanded by 70% of terrestrial area. Thus further expansion is prohibited by the pact to prevent a total ecological collapse. To this, the pact has a period of validity (10 hours) and must be extended by reaching the global consensus with other stakeholders. The extension, in-turn, requires substantial amount of financial resources.

For this, players (as well as other organizations) must accumulate financial resources in advance and submit the payment when the time is due. For three game hours, an animated GUI icon will notify players of the amount of payment and time remaining. The amount of payment will be slightly decreased if players' international influence is high (see influence factor section). For example, players with 15 international influence points will pay 3,000,000 points of wealth while players with 30 international influence points will pay 2,350,000 (21.67% decrease).

In regard to the concept of dynamic in-game value (see Dynamic In-game Values), the amount request will vary from one cycle to another. For example, the game will randomly pick up values from the range of 2,500,000-5,000,000.

Failure to extend the pact will result in population expanding into the remaining natural habitat. To this, base environmental degradation rate will be permanently increased by 25% for each time

players have failed to extend the pact. Players lost the game upon the third time they have failed to extend the pact.

7. Expanded animation and video animation

As commented by some participants, the current version of THE GROWTH lacks elaborated animation. The next iteration aims to increase the use of animation (e.g. animated game objects, animated lights, and animated GUIs). Further, it is suggested that short video animation could be used in the game to improve visual engagement.

8. Expanded visual dynamic

Figure: The original version of a medium-sized luxury apartment (left) and the same building with solar pavement, solar panels, and solar paint enabled (right).
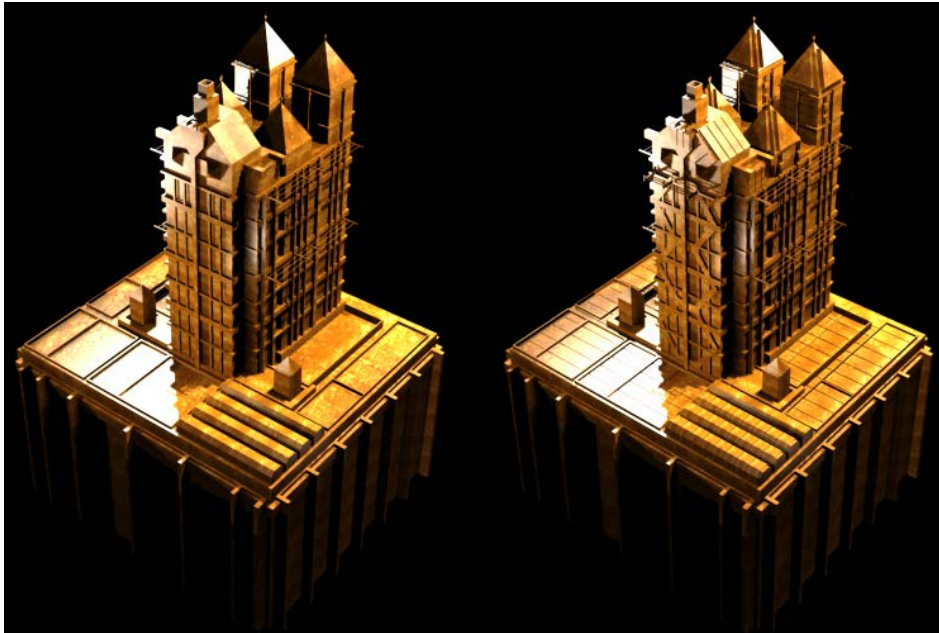
Apart from visual clues such as animated lights and smokes that signal environmental pollution, the current version of THE GROWTH has limited degree of visual dynamic. In the next iteration, game objects can be altered based on players' actions. For example, solar panels will appear on building surface once players have install solar panels on them (see a figure below). On the other hand, trees will undergo defoliation and the colour of water in the river will turn to rusty colour when the environmental condition in the region is failing.

Due to a disastrous industrial explosion (as described by the game story), buildings are appeared in yellowish-rustic colour when the game first started. To this, the next iteration of the game would allow players to 'clean-up' purchased buildings once the environmental condition in the region has reach positive level (e.g. ~65%). The cleaning process requires financial resources and will generate 'one-time' environmental pollution (from paints and other materials required for the renovation). Cleaned residential buildings will generate extra profits for players by 10-30% (i.e. value added). However, cleaned buildings will revert back to yellowish-rustic colour if the environmental condition in the region falls below acceptable standard (e.g. ~40%).

As with other game mechanism, this renovation mechanism aims to address financial benefits from environmental conservation.

9. Introducing the fifth factor: Influence factor (local & international influence)

Figure: The influence factor locates beneath the wealth factor. Left area represents local influence while the right area represents international influence.
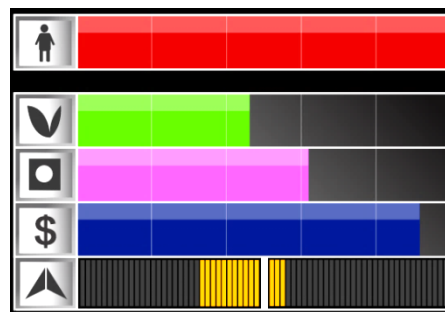

Figure: Explicit information is provided when a cursor is hovered on the GUI.

The influence factor will be the new factor of the next iteration (see a figure above). The influence factor represents players' political power that could be exercised to assist in environmental and social development projects. Similar to other resource types, certain influence points will be consumed once activated by players. Influence factor is further separated into the local and the international influence.

The local influence can be used to increase successful rates of policy making and investments in the region. Further, the local influence can be used to shorten the recharge time for the special actions (see special action section in the game chapter).

The international influence, on the other hand, represents players' level of recognition on international forums. The international influence can be used to gain access to international development projects (see GEO section). Below are the key characteristics for the influence factor:

- Influence points can be gained by: 1) fulfilling requests offered by events (see decision-making events section) 2) completing quizzes (for each correct answer, there is a 1% chance that players will receive 1 point in either the local or the international influence.

- Unique positive random events (e.g. financial and other public supports) will occur in the region once regional influence is equal or greater than 60% of the total capacity. Subsequently, additional positive random events will occur in the region for even higher level of influence.

- Inactive use of quiz function will reduce regional influence points by 1 (for every 15 minutes of inactivity). This aspect represents the inadequacy of environmental activities – causing the public to disregard the importance of the environmental conservation. On the other hand, the game pressures players to use quiz function in order to reinforce the active learning aspect of the game.

10. Natural fertility

Figure: Fertility management panel. On top left, players can view current level of fertility within the natural reserves. Several options are available where players can: 1) sacrifice financial resources to nurture this natural reserve 2) allow locals to gather forest products with moderate risk of negative environmental consequences, and 3) permit hunting and logging in this natural reserve to gain a substantial, albeit short term profits from the natural reserve. The third option decreases fertility, may escalate illegal hunting situation, and may upset other environmental organizations. It should be noted that the third option in the figure is currently unusable due to insufficient fertility level – at least 65% fertility is required to initiate this option.

The fertility management panel can be accessed via a GUI in the purchased natural reserves. The concept of fertility allows trees and wildlife species in 'acquired' conserved forests to flourish slowly overtime (also applies to other natural reserves such as natural caves and marine sanctuaries). Visually, the density of trees and wild animals will increase when the fertility level of the natural reserves is high (see Expanded visual dynamic section). In regards to game dynamic, fertile conserved forests will provide more environmental points to the region than conserved forests

initially purchased by the players. Further, fertile conserved forests will increase public donation as well as eco-tourism rates (if eco-tourism is established in the said natural reserves).

Three options are planned to be incorporated into fertility function. The first option would allow players to slightly accelerate the fertility speed of a chosen natural reserve. A considerable amount of financial resources and emergency supplies are required for this task. Fertility gains will be depended on the current status of the natural reserve. For example, if this option is triggered on a forest with 20% fertility, the fertility will be increased by 2-5% while a forest with 50% fertility will experience the increase of 7-8%. This aspect aims to simulate difficulties in restoring a heavily damaged ecosystem. Once triggered, players must wait for 15-25 minutes before this option can be triggered again.

For the second option players would be able to give permissions to local villagers to harvest forest product sustainably and share the profit with the forest management. Only natural reserves with at least 40% fertility would be able to use this option and it will be cancelled automatically once the fertility level has fallen below 30%. The income rates will be corresponded to the level of fertility. For example, a conserved forest with 50% fertility level and the sustainable harvest policy enabled will provide 2-5 points of wealth for players per second while the same conserved forest with 70% fertility level will provide 3-8 points of wealth per second. This policy, however, contains negative random events such as 'wildfire' and 'overharvest' to simulate risks associated with human activities (fertility of the conserved forest will be reduced should these events occur). Nonetheless, these risks can be reduced either by investing in 'environmental education' policy and/or 'strict harvest quota' policy. Sustainable harvest policy can be cancel anytime, but it is possible that the cancellation will trigger a protest from the locals (from losing their source of income).

For the last option, players can sacrifice the fertility level of the natural reserves for financial resources (representing hunting and logging permits). Only the natural reserves with at least 65% fertility would be able to use this option and it will be cancelled automatically once the fertility level fell below 50%. There is a high probability that using this option will decrease players' local influence points (see influence factor section). Further, there is a high probability that using this option will cause other environmental organizations to withdraw their supports from players. Nevertheless, this option can be seen as the last resort for players in critical need for financial aids.

11. Dynamic In-game Values

Rewards and punishment points in the current version of THE GROWTH are consisted of static value. For example, during a public donation event, the game will reward a static amount of 25,000 points of financial resources to players. For the next iteration, however, the game will randomize the range of reward from 15,000-25,000 (e.g. players may receive a reward of 18,250 points of wealth for the first time this event occurs and then 23,547 on the second time).

Similarly, the value of long-term rewards such as beneficial effects from upgrades and investments will be dynamic. For example, a high-rise building may give players 20 points of wealth per second during the first 60 seconds then 15 points per second for the next 60 seconds.

12. Improved upgrade function

Several aspects of upgrade function are planned to be revised in the next iteration. These include:

- **Ability to cancel upgrades:** This function could be useful for players who wish to remove active upgrades from the game. For example, players may need to cancel 'high-financial-upkeep' upgrades such as 'marine protection program' which consumes considerable amount of financial and supply resources overtime. This strategy could be useful when players are running low on resources. On the other hand, players may consider removing 'animal carcass trade' from the inventory in order to avoid provoking environmental activists in the region. As mentioned earlier, players may be penalized for cancelling some upgrades / policies (see 'Fertile conserved forest' section).

- **Upgrade set system:** For example, by having 'Level - 1 Recycling Campaign', 'Plastic Bag banning', and 'Level 2 - Environmental Education' upgrade active at the same time, recycling rate in the region will be boosted by 20%[1]. This bonus will cease once one of the three upgrades mentioned above has expired.

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[1] By default, there is a 20% chance for every 15 minutes that the population in the region with 'level - 1 recycling campaign' will participate in recycling campaign (positive random event). In case of the new upgrade set discussed above, the chance of participation in recycling will be increased to 40%. Congruently, if the player has a 'level - 2 recycling campaign' upgrade, the chance of participation in recycling will be increased to 56%, and then 70% for the 'level - 3 recycling campaign' respectively.

- **Upgrade queuing:** Players would be able to put upgrades in 'queue' so the cycle of re-upgrade can be performed automatically[2]. The system will calculate time required to complete an upgrade as well as the chance of success for the first queuing upgrade (in a similar fashion to manual upgrade system). If this first queuing upgrade has failed to be implemented, the system will discard it (players lost a fraction of resources in the process). The system then jump to the next upgrade in the queue and attempt another calculation. If this second queuing upgrade has succeeded in implementation, the queue will stop until the second queuing upgrade is moved into an active slot (i.e. in-use state). The cycle then resumes again until there is no upgrade left in the queue.

- **Customize upgrade system:** The next iteration will see the possibility in upgrade customization (see the figure above). This improves upgrades' performances and / or improves the rate of successful implementation. For example, combining 'Energy Efficient Appliance' technology with 'Level 1 - durable material' technology and 10 'Influence Points' will increase the success rate of 'Energy Efficient Appliance' by 20% while extend its lifetime by 250%. The purpose of this customization feature is to improve the dynamic learning aspect of the game – promoting both active and experiential learning. The formulae for each combination will be pre-defined by the script in order to prevent unexpected combination (which could implicate learning outcomes). A GUI will appear to inform players about incompatible upgrades.

Figure: The upgrade customization panels (left image). Up to three base upgrades can be combined to create a new custom upgrade. In lower left area of the left image, players can also add local influence points to increase the successful rate of the new custom upgrade. Players can select on the desire output (lower right icon) to expand information and statistics about the custom upgrade (right image).

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[2] In AGE OF EMPIRES II for example, farms will eventually exhaust and the field needs to be plowed again. By having queuing system, the cycle can be put in queue where workers will re-plow the field automatically (resources for plowing are consumed in advanced for each queue).

13. Improved Sub-Upgrade function

Figure: the concept of improved sub-upgrade function where players can execute sub-upgrade commands directly from the game scene. The figure shows sub-upgrade options for a high-rise accommodation: Renewable Technology, Improved Resources Management Protocol, Systematic Waste Management Module, and Space Optimization Program respectively.
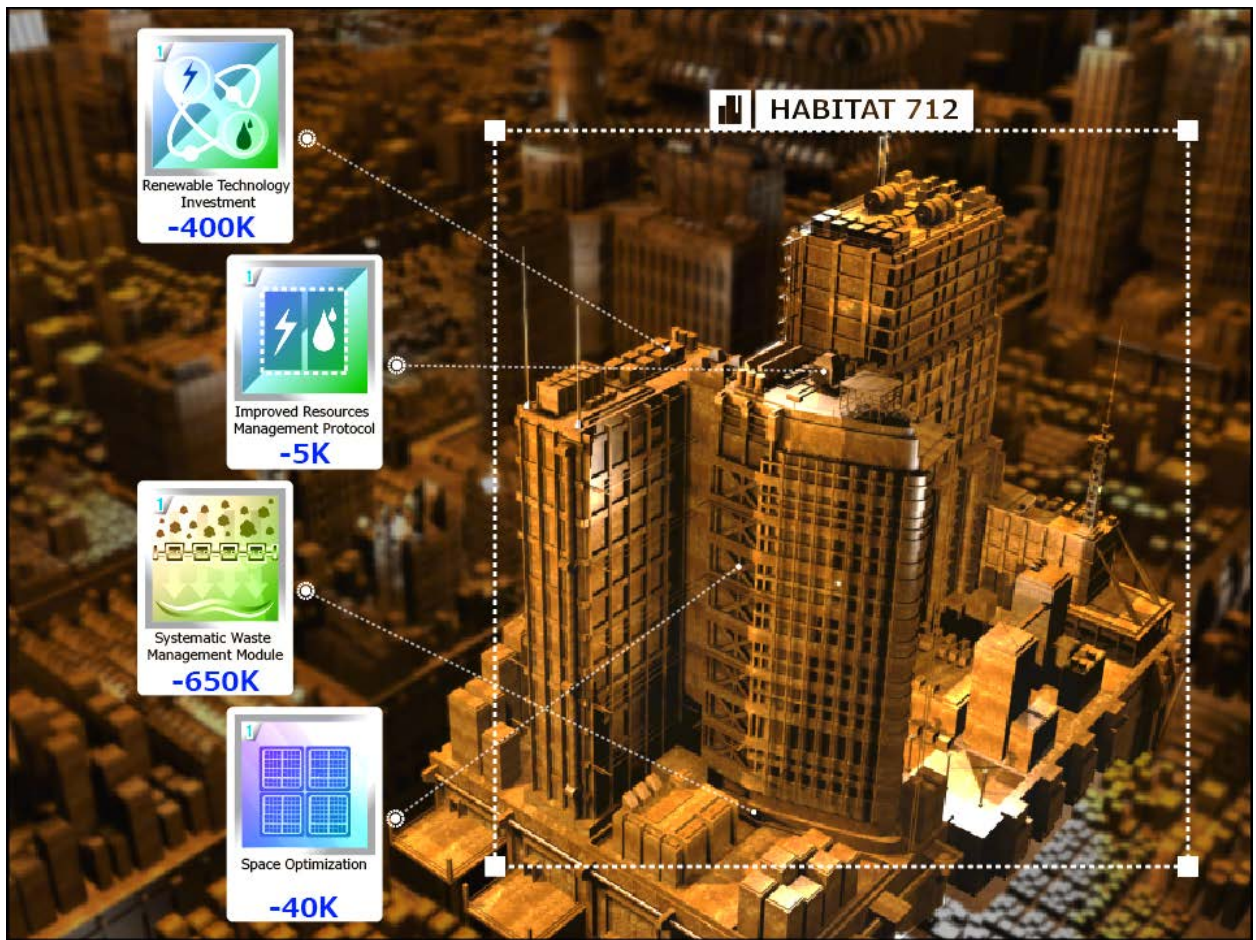
As mentioned in THE GROWTH chapter, the sub-upgrade is referred to additional upgrades that can be performed on purchased buildings in order to gain additional environmental and financial benefits.

The game scene of the current game version serves no other purposes rather than showing the vast man-made cityscape while animated lighting and smog effects serves as the pollution level indicator.

The next iteration, however, will see an improved sub-upgrade function where players would be able to execute sub-upgrade commands directly from the game scene. As shows in the figure above, sub-

upgrade options appear as players select on the building. Links will be made between sub-upgrades and their respective part of the building (e.g. linking the solar panel upgrade to the rooftop area of the building).

By right-click on the upgrade GUI, the pop-up window will appear and give detailed information about the selected upgrade item to players.

Players would still be able to access sub-upgrade commands via the 'traditional' sub-upgrade menu as usual. The purpose of the new system is to enhance flexibility of the gameplay as well as improve players' interaction (i.e. presence) with the game environment.

14. Introducing the research function

Figure: an improved research system
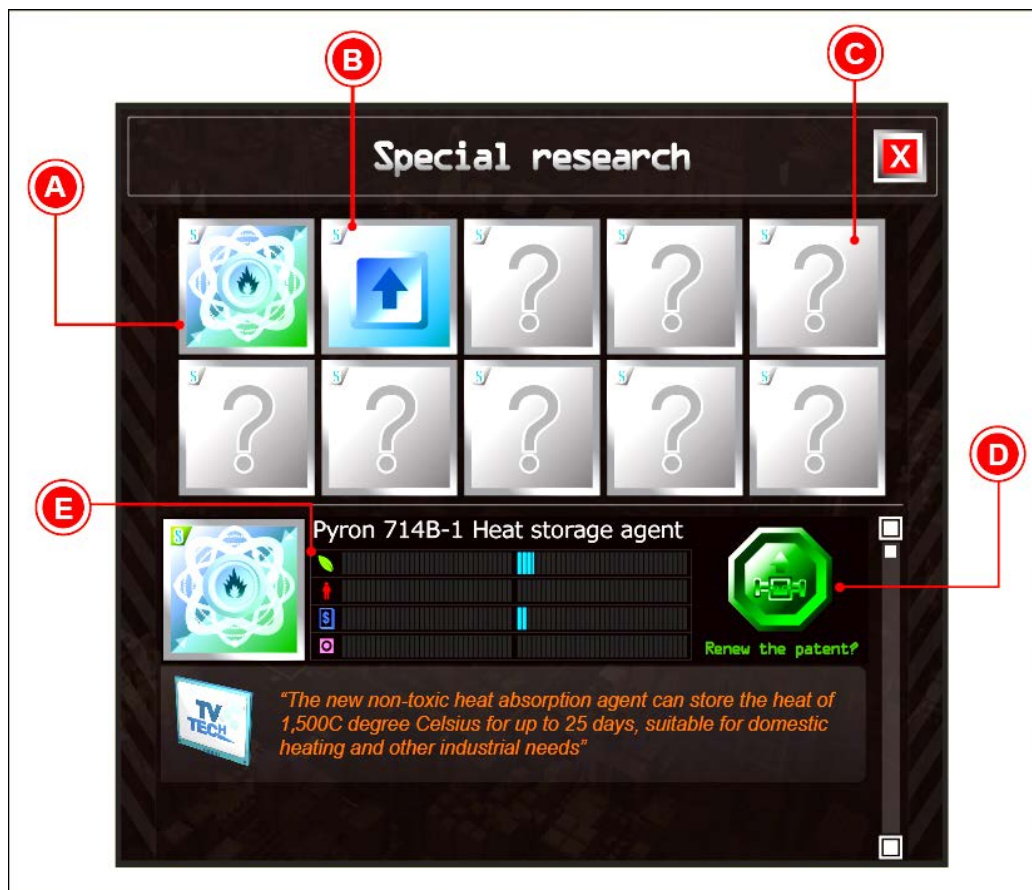
There is a building called 'Advanced Research Facility' in THE GROWTH. Once purchased, there's a small chance for every 20 minutes that the facility will succeed in their research projects – contributing enormous, albeit one-time benefits for the players every time the researchers have succeeded in their research projects.

To this, the next iteration will see a new dedicate research system where major scientific breakthroughs will be more difficult to acquire, but will generate benefits to the players (and the region) over time. For example, the figure above shows the recently acquired major scientific technology – the novel heat storage agent (A). This new technology contributes to environmental benefits as heat energy from renewable sources can be stored for an extended period of time, reducing reliance on fossil-fuel sources. This scientific development also contributes to financial benefits as well.

There's a small chance (1%) for every 20 minutes that the new major scientific technology will appear in players' inventory (up to the maximum of 10 items, as shown in the figure above). However, players would be able to allocate financial resources to increase the successful rate of the discovery for up to the maximum rate of 2% (B). The grey GUI icons (C) show scientific breakthroughs that are yet to be discovered. Benefits provides by the technology over the period of time is shown in (E), which is similar to the main upgrade / investment function.

These major scientific technologies, like other upgrade items, will expire after a certain period of time. Unlike other upgrade items, however, players won't be able to re-invest in expired major technological item (represents out-of-date patent items that have been released to the public).

To retain the financial benefits provided by the major scientific technology, players need to renew the patent (D). A GUI will appear on the screen to warn the players once the patent has lower than 26% of its lifetime.

Although major technological items released to the public won't generate financial benefits to the players, they will generate additional beneficial effects to the natural environment (if any). For example, the novel heat storage agent as shown above will, by default, generate 16 environmental and 80 financial points to the players every second. If the players have failed to renew the patent in time, this technological item will be released to the public and generate 19-27 environmental points per second (18.75-68.75% increase from the default environmental benefits), but not the financial points. This aspect aims to simulate the reduced technological cost that encourages the business and industrial sectors to invest in environmental-friendly and long-term cost reduction technologies.

THE GROWTH will retain its 'traditional' research system where minor research projects will still contribute one-time benefits for the players over the game session.

15. Introducing The Global Environmental Organizations (GEO)

In recognition of transferable environmental and social impacts from other regions (e.g. pollution, invasive species, diseases, and wars), the next iteration of THE GROWTH will include the aspect of 'Global Environmental Organizations' or GEO to depict cooperative scenarios between environmental organizations worldwide. The following are planned mechanisms for the GEO function:

- **Shares in intercontinental projects:** In this scenario, players are invited by GEO to pool their resources into intercontinental projects such as 'A Marine Sanctuary', 'An Advanced Scientific Complex', or 'An International Investment Company'. This new system shares key similarities to the existing investment function. However, players cannot invest in these projects unless invited by the game (i.e. GEO's representative). That is, players will be periodically invited to participate in each project. Larger projects require that players must possess a relatively high level of international influence in order to be invited (see the influence factor section). Once a share has been acquired, players can periodically increase the amount of shares in the subsequent invitations up to the maximum of 80% of total shares in each project.

  For example, after 2 hours into the game, players are invited to contribute 800,000 points of financial resources in exchange for a share in a marine sanctuary. Players now have 25 minutes to gather the necessary resources and make a decision. Once acquired, this 10% share generates 8-13 points of financial resources per second for the players (from eco-tourism). There is also a 15% chance for every 20 minutes that this marine sanctuary will experience a boost in eco-tourism, generating a bonus of 80,000-100,000 points of wealth for players (see random events in game chapter). After 5 hours into the game, players are invited once again to contribute an additional of 1,150,000 points of financial resources in exchange for an increase of the share to 20% and the return of 11-17 points of wealth per second.

  Similar to the investment function, players can customize this marine sanctuary further. For example, an option exists where players with a 10% share can propose an 'exotic animal trade' policy which allows the harvest and sale of some wild animals from this marine sanctuary in return for the extra profits but containing risks of upsetting environmental organizations

worldwide. With only a 10% share, players would have just 5% chance for the successful lobbying of this proposal while players with a 50% share would have 35% chance of success.

On the other hand, another option exists where the players can increase the frequency of patrols around this marine sanctuary in order to gain additional environmental points, albeit at the increased operational cost (e.g. manpower, fuel, and boat maintenance cost). The chance of successful lobbying for this proposal is also higher due to perceived supports from GEO members. Players with a 10% share would have 20% chance of success on lobbying this proposal.

- **International events:** In certain random events, GEO may ask players for resources assistance. Fulfilling these requests will increase players' influences on international forums (see influence factor section). On the other hand, refusal may decrease players' international influences. For example, GEO asks players to contribute 9,000 emergency supplies to assist a marine protection task force operating in the northern sea. Fulfilling this request within 20 minutes will increase players' international influences by 2 points while refusing to this request runs a 70% risk of losing 1 international influence point.

16. Decision-making random events

Apart from the random event that has already been implemented into the current version, the next iteration will see another type of random event which requires players to make decisions.

For example, a decision-making random event may present a scenario of war refugees and ask the players to accept refugees into their region. Fulfilling this request will increase the players' regional influence points by 3 (see influence factor section), but will consume 2 emergency supplies per second for 280 minutes and can trigger another random event of 'escaped refugees' where certain amount of population will be added to players' region. Refusing this request, however, runs 75% risk of losing 2 influence points.

17. Season-based events

The next iteration of THE GROWTH will see an introduction of seasons such as summer, rainy, and winter. In regards to the 'Expanded visual dynamic', visual effects of increased light intensity (summer), snowballs (winter), and the heavy rain (rainy season) will be introduced into the game. A cycle of seasons will be completed in 120 minutes. A standard cycle would consist of summer (40 minutes), rainy (40 minutes), and winter (40 minutes). However, the length of seasons can be

differed for each cycle. For example, the second cycle may consist of summer (54 minutes), rainy (37 minutes), and winter (29 minutes).

Some random events will be attached to these seasons. For example, players can expect for increased water usage, draught, locust swarm, and forest fire disasters during summer season. Floods and infrastructure failure may occur more frequently during rainy seasons. On the other hand, winter will see increased energy consumption rate, disease outbreaks in livestock, and crop failure.

However, bonus for some upgrades that players may have implemented prior to the beginning of seasons will be increased. For example, if the 'Solar Cookers' and other solar powered upgrades were implemented in the region during summer season then the overall energy consumption rate will be reduced, contributing bonus environmental points to the region. On the other hand, if 'insulated indoor tents' were manufactured prior to winter season then the energy consumption rate will be reduced.

Seasons can influence bonus points being gained from investment function (i.e. business) as well. For example, the energy output from the 'Solar Towers' will be decreased by 50-70% during the rainy season. Profits from the 'Communication Centre' will be increased during winter season (if players have invested in networked pipes that divert and sell waste heat from the centre to nearby buildings for space heating). On the other hand, 'Wind Farm Complexes' without 'Anti-Icing Blade Coating' upgrade will suffer additional maintenance cost during the winter season (i.e. reduced financial gains).

18. Expanded UI, Hotkeys, and Feedback system

The importance of UI and feedback system was highlighted in GEG chapter. Based on participants' reception, the future work of THE GROWTH aims to expand the following feedback system:

- **Inform players of success and failure on upgrades / improvements:** A notification dialogue box could be used to inform players of success and failure on upgrades / improvements. When selecting this dialogue box, the game prompts players to confirm the decision of re-upgrade.
- **Notification when an upgrade is expiring:** In the next iteration, feedback system should notify players when upgrades are expiring. Further, players should be able to put upgrades in 'queue' so the cycle of re-upgrade can be done automatically.
- **Tooltip box:** Following some participants' suggestions, tooltip boxes could be used to give information about game GUIs and other elements. For example, while a cursor is hovering on an investment GUI button and the key 'x' is pressed, a tooltip box appears and explains investment

mechanism for players. The tooltip box can be superior compared to the standard 'readme' tutorial and can be linked to what Gee (2003) described as "information on demand".

- **Turn-off minor notifications:** In the next iteration, notifications from minor game events (e.g. insignificant resources gains / loss) can be turn-on / off by players to prevent distraction and cognitive load.

- **Hotkeys:** 'ESC' button can be used so players can close dialogue boxes easily without having to move a cursor to a 'close' button (e.g. press 'ESC' while on expanded-upgrade screen should return players to the main upgrade panel while pressing 'ESC' again should return players to the main game scene.

Further, game functions could be called simply by pressing hotkeys. For example, pressing F1 to review tutorial pages, F2 for game story, and F3 for quiz function. Hotkeys customization might be considered so players can assign hotkeys according to their preferences.

19. Up-to-date information & expanded content

In concordance to the 'Up-to-date' game context highlighted in the GEG chapter, contents in THE GROWTH will be updated to keep players informed about recent environmental, social, and technological events.

Further, new game contents (e.g. upgrades and investments) will be included into the game to highlight innovative policies and technologies that could be used to tackle environmental and social issues.

20. Expanded content

In concordance to 'Up-to-date' game context highlighted in GEG chapter, new contents will added into the next iteration of THE GROWTH. 'The Floating Algae Farm' and 'The In-vitro meat facility' are among the upcoming addition. For example, an advanced facility dedicate to cultured meat products (i.e. In-vitro meat) will be the new purchasable business for the players (decrease environmental impacts from the farm sectors).