THE MODERATING EFFECTS OF ENVIRONMENTAL AWARENESS AND ENVIRONMENTAL MOTIVATION ON THE RELATIONSHIP BETWEEN REWARD-BASED GAMIFICATION AND PRO-ENVIRONMENTAL BEHAVIOUR: A CASE OF ALIPAY'S ANT FOREST

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2024

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by

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Thesis submitted in fulfilment of the requirements
for the degree of
Doctor of Philosophy

July 2024

ACKNOWLEDGEMENT

When I finished my thesis and started sorting out the format, I had a lot of thoughts. Unexpectedly, more than three years have passed by in a flash. I still remember that COVID-19 started to spread nearly four years ago and slowed down the pace of my life, so I started thinking about my future direction as a university lecturer and researcher. First of all, I would like to thank Universiti Sains Malaysia (USM) for the choice of a brand-new direction which combines gamification and environmental communication, allowing me to start a new life as a doctoral candidate. I am even more grateful to my main supervisor, Dr. Mohamad Saifudin Mohamad Saleh (Dr. Sai) (Deputy Dean of Academic, Career and International, School of Communication, USM), for being able to choose and guide my research among many applicants.

I am undoubtedly lucky to be able to collaborate with Dr. Sai on research. His professional knowledge and rigorous attitude have become my role models. I still remember my haste at the beginning, but Dr. Sai put my research on the right track through his patience and logical guidance. Throughout the entire research process, Dr. Sai always maintained an attitude of equality, tolerance and wisdom to help me overcome each difficulty. In addition, I am extremely grateful to my co-supervisor, Associate Prof. Dr. Izzal Asnira Zolkepli. Dr. Izzal's professional insights on research methods and suggestions for journal papers further improved my research. The guidance of the two supervisors broadened my horizons and gradually transformed me from a practical lecturer from China into an international researcher, which has played a huge role in promoting my career development. No words can fully express my respect and gratitude to these two supervisors. I very much look forward to continuing our research with them after

completing my PhD.

Moreover, I got a lot of help from the research team organised by Dr. Sai. Previous doctoral candidates Naziru Alhaji Tukur and Ali Mehellou introduced me to many research experiences and jointly completed several journal papers under the leadership of our supervisor. From them, I gained a more intuitive understanding of USM's doctoral research progress. Several master students of Dr. Sai in the team also gave some new ideas. I'm extremely grateful to them for their cooperative spirit.

During the research process, Associate Prof. Dr. Hasrina Mustafa and Dr. Mohd Heikal Husin, as proposal review experts, gave me many valuable opinions. Dr. Mohd Khairie Ahmad, Dr. Abdulrahman Bello Bada, Associate Prof. Dr. Daniel Fischer and Prof. Dr. Xie Bei served as an expert panel on research methodology and helped me improve the questionnaire. Two industry experts, Zhang Tong and Ma Xun, helped me contact the human resources needed for the research. I would like to express my highest respect to the above-mentioned scholars and experts who have guided and helped me. Without their help, my research would not have progressed smoothly.

Finally, I would like to thank the Communication University of China, Nanjing, which set aside time for me and supported me to study in Malaysia, and the School of Animation & Digital Arts which I belong. My colleagues shared my tasks so that I could be here to study and research with peace of mind. I look forward to meeting them.

The pleasant climate in Penang and the green USM campus made me enjoy my study time in Malaysia. I would like to thank the warm and friendly people of Penang and all the lecturers and staff at USM who have helped me. My family spent this unforgettable time in Penang with me. This experience will become my most precious memory.

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LIST OF SYMBOLS

CO_2	Carbon Dioxide
$PM_{2.5}$	Particulate Matter Diameter Less than 2.5 Micrometers
n	Number
z	Standard Normal Variable at a Given Confidence Level
σ	Standard Deviation of the Population
e	Acceptable Error
M	Mean
Rho_a	Composite Reliability (rho_a)
β	Std. beta
p-value	Probability Statistics
t-value	Test Statistics
R^2	Coefficient of Determination
f^2	Effect Size
Q^2	Predictive Relevance

LIST OF ABBREVIATIONS

AR	Augmented Reality
ASEAN	Association of Southeast Asian Nations
AVE	Average Variance Extracted
CA	Cronbach's Alpha
CCA	Confirmatory Composite Analysis
CFA	Confirmatory Factor Analysis
CMV	Common Method Variance
CNY	Chinese Yuan
COVID-19	Corona Virus Disease 2019
CR	Composite Reliability
CVI	Content Validity Index
EFA	Exploratory Factor Analysis
EPI	Environmental Performance Index
ERIA	Economic Research Institute for ASEAN and East Asia
ESMM	Explanatory Sequential Mixed Methods
ETH	Eidgenössische Technische Hochschule
Freq.	Frequency of Occurrence
GDP	Gross Domestic Product
HAB	Harmful Algal Blooms
HCI	Human-Computer Interaction
HTMT	Heterotrait-Monotrait
IBM	International Business Machines (Corporation)
ICT	Information and Communications Technology
ID	Identification

IoT	Internet of Things
IRT	Item Response Theory
JEPeM	Jawatankuasa Etika Penyelidikan Manusia
KAP	Knowledge Attitude and Practice
LM	Linear Model
MAXQDA	Max Qualitative and Quantitative Data Analysis (Software)
MAE	Mean Absolute Error
MENA	Middle East and North Africa
PEB	Pro-Environmental Behaviour
PhD	Doctor of Philosophy
PIP	Pillar Integration Process
PLS	Partial Least Square
QUAL	Qualitative
QUAN	Quantitative
RMSE	Root Means Squared Error
RO	Research Objective
RQ	Research Question
SD	Standard Deviation
SDG	Sustainable Development Goal
SEM	Structural Equation Model
S-O-R	Stimulus-Organism-Response (Theory)
S-R	Stimulus-Response (Theory)
SPSS	Statistical Package for Social Sciences (Software)
TA	Thematic Analysis
TPB	Theory of Planned Behaviour
TRA	Theory of Reasoned Action
USA	United States of America

USM	Universiti Sains Malaysia
VIF	Variance Inflation Factor
WHO	World Health Organisation
WJX	Wenjuanxing (Software)
ZHdK	Zürcher Hochschule der Künste

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KESAN PENYEDERHANAAN KESEDARAN ALAM SEKITAR DAN MOTIVASI ALAM SEKITAR TERHADAP HUBUNGAN ANTARA GAMIFIKASI BERASASKAN GANJARAN DAN TINGKAH LAKU PRO-PERSEKITARAN: KAJIAN KES ANT FOREST OLEH ALIPAY

ABSTRAK

Untuk menangani isu alam sekitar yang disebabkan oleh daripada pembangunan ekonomi yang pesat, sebuah permainan alam sekitar yang dinamakan *Ant Forest* dibangunkan oleh Alipay dan digunakan untuk menyokong kesedaran hijau di China. Mekanisme permainan *Ant Forest* membolehkan pengguna mengubah ganjaran menjadi pokok sebenar. Kajian ini menggunakan teori Stimulus-Organism-Response (S-O-R) sebagai teori asas dalam menganalisis hubungan langsung antara ganjaran gamifikasi, daya pujukan dan pro-persekitaran (PEB), serta menganalisis kesan kesedaran dan motivasi alam sekitar sebagai pemboleh ubah penyederhana. Kajian ini menggunakan kaedah campuran penjelasan berurutan untuk mencapai objektif kajian. Pada fasa pertama, 621 orang pengguna *Ant Forest* telah mengambil bahagian dalam soal selidik dalam talian dan menghasilkan keputusan analisis kuantitatif. Pada fasa kedua, pengkaji telah memilih 12 orang peserta daripada fasa pertama untuk ditemu bual secara bersemuka. Hasil tinjauan menunjukkan bahawa gamifikasi berasaskan ganjaran boleh digunakan sebagai kaedah merangsang yang sangat berkesan untuk mempromosikan PEB pengguna. Rangsangan berfungsi terutamanya melalui daya pujukan *Ant Forest* terhadap pengguna. Penemuan yang lebih penting dalam kajian ini ialah ia membuktikan bahawa kesan penyederhanaan kesedaran alam sekitar terhadap hubungan antara daya pujukan dan PEB, manakala motivasi alam sekitar tidak menunjukkan kesan penyederhanaan. Kesedaran alam

sekitar memberi kesan sederhana kerana ia boleh membawa pengetahuan alam sekitar, pencapaian bermakna, maklum balas positif, peringatan harian dan kesan kumpulan kepada pengguna. Kegagalan motivasi alam sekitar untuk memberikan kesan penyederhanaan adalah disebabkan oleh kekeliruan motivasi alam sekitar dan hiburan, dan jurang antara motivasi alam sekitar dan tingkah laku. Secara keseluruhan, kajian ini menjelaskan kesan positif gamifikasi berasaskan ganjaran ke atas PEB pengguna berdasarkan teori S-O-R, dan menunjukkan kesan penyederhanaan positif kesedaran alam sekitar. Penemuan ini memberikan dorongan penting untuk penyelidikan tentang kesan aplikasi mudah alih ke atas pengguna, dan menjadi teori asas untuk pembangunan aplikasi mudah alih masa hadapan.

THE MODERATING EFFECTS OF ENVIRONMENTAL AWARENESS AND ENVIRONMENTAL MOTIVATION ON THE RELATIONSHIP BETWEEN REWARD-BASED GAMIFICATION AND PRO-ENVIRONMENTAL BEHAVIOUR: A CASE OF ALIPAY'S ANT FOREST

ABSTRACT

In order to cope with the environmental issues caused by rapid economic development, an environmental game called Ant Forest, developed by Alipay, is used to advocate green awareness in China. The game mechanism of Ant Forest allows users to transform rewards into real trees. This study applied the Stimulus-Organism-Response (S-O-R) theory as the theoretical foundation, analysed the direct relationships between gamified reward, perceived persuasiveness and pro-environmental behaviour (PEB), and analysed the effect of environmental awareness and motivation as moderating variables. The study uses the explanatory sequential mixed methods to achieve the study objectives. In the first phase, 621 Ant Forest users participated in the survey through online questionnaires and this resulted in quantitative analysis results. In the second phase, the researcher selected 12 participants from the first phase to interview them face-to-face. The survey results show that reward-based gamification can be used as a very effective stimulating method to promote users' PEB. The stimulus work primarily through Ant Forest's perceived persuasiveness on users. The more important finding of this study is that it proved the moderating effect of environmental awareness on the relationship between perceived persuasiveness and PEB, while environmental motivation does not show the moderating effect. Environmental awareness can exert a moderating effect mainly because it can bring environmental knowledge, meaningful achievements, positive

feedback, daily reminders and group effects to users. The failure of environmental motivation to exert a moderating effect is mainly due to the confusion of environmental and entertainment motivations, and the gap between environmental motivation and behaviour. Overall, this study clarifies the positive effect of reward-based gamification on users' PEBs based on the S-O-R theory, and points out the positive moderating effect of environmental awareness. These findings provide important impetus for research on the effects of mobile applications on users and become the theoretical foundation for future mobile application development.

CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter briefly introduces the background of the study and problem statement. This chapter also presents the study's objectives and research questions. The significance, scope and concept definitions that were deemed relevant to the study are presented as well. The study structure is presented at the end of this chapter.

1.2 Study Background

In recent years, China's economy has developed rapidly and grown into the world's second-largest economy (Yang et al., 2020a). However, the ensuing environmental issues have become increasingly prominent (Zhao et al., 2022a). Despite the Chinese government's vigorous regulation, environmental issues still affect the national economy and the people's health (Xu, 2023). At the beginning of 2020, the spread of COVID-19 [1] ceased the production activities in China, resulting in the significant reduction in the use of fossil fuels. However, large-scale pollution exceeding $PM_{2.5}$[2] standards and haze pollution still occur in Shanghai and other East China regions (Wang, 2020). Desertification in northeast and northwest China is another a serious issue that causes environmental and economic losses to the people and the surrounding areas; this has been included in the national priority governance issue (Zhang & Huisingh, 2018).

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[1]COVID-19 is the abbreviation for Coronavirus Disease 2019.

[2]$PM_{2.5}$ is the abbreviation for particulate matter diameter of less than 2.5 micrometers.

In response to these environmental issues, China has promoted a large number of afforestation projects to expand the green areas and make significant contributions to the world's environmental protection (Chen et al., 2019). Since 1978, the Chinese government has initiated many large-scale environmental protection projects (including restoration of vegetation, sandification control, water resource management, and comprehensive agricultural development) to prevent desertification, and most of them have had positive effects (e.g., the Grain for Green Programme and the Natural Forest Conservation Programme) (Bryan et al., 2018). However, in the face of the complex status quo of China's environmental issues, the government often adopts performance supervision to implement top-down policies, and there are insufficient studies on bottom-up methods, such as public scrutiny (Wu et al., 2018).

Modern gamified applications can recreate scenes with virtual reality after the environment has been destroyed, so that users can get real experiences (Esmaeili & Thwaites, 2021). These experiences were proven to awaken users' environmental awareness (Esmaeili & Thwaites, 2021). Survey data from five research universities in Malaysia showed that diverse gamification elements can create a game-like activity environment for users, thereby enhancing their intrinsic motivation to participate in energy-saving behaviours (Wee & Choong, 2019). Focusing on enhancing the effectiveness of environmental education through the Internet of Things (IoT) and gamification, Rodosthenous et al. (2022) demonstrated that gamification can stimulate learning interactions and help students establish environmental awareness. In addition, Frías-Jamilena et al. (2022) demonstrated the positive effect of gamified environmental explanations on attraction visitors in terms of pro-environmental knowledge, attitudes, and behaviours. In short, more gamification elements in a mobile app create stronger

physical and mental connections for the participants, which can effectively influence behavioural changes (Ouariachi et al., 2020).

Moreover, the development of China's mobile Internet provides opportunities for anyone to participate in public environmental protection (Yang et al., 2018). As China's largest online payment platform, Alipay launched the gamification feature Ant Forest in 2016 (Chen et al., 2020), and 550 million users had joined its environmental-themed online community by 2020 (Zhang et al., 2022). Users can set up a virtual carbon account in Ant Forest and convert their completed PEBs into virtual energy points to support the growth of virtual trees (Ashfaq et al., 2021). The virtual trees are designed as cartoon appearances, grow gradually as users collect energy points, and can eventually be exchanged for real trees to be planted in desert areas in China with the financial capital support of Alipay (Zhang et al., 2022). As for its application process, 24 types of daily environmental activities, such as green travel, mobile payment, public transportation, and second-hand goods recycling, are recorded and exchanged for the corresponding green energy points, which can be "shared," "stolen," and "earned cooperatively." (Wang & Yao, 2020)

Pro-Environmental Behaviours (PEBs) that can be recorded and converted into virtual energy points through Ant Forest include renting shared bicycles, using electronic invoices, paying for public transportation, purchasing green products, etc. (Zhang et al., 2020e). This process makes users to understand their contributions to environmental protection to encourage them to continue these PEBs (Chen & Cai, 2019). Completing PEBs in such a gamified interactive form stimulates users' positive emotions towards loving the natural environment (Dong et al., 2023). After gaining public recognition, Ant Forest continued to develop advanced functions such as Ant

Farm, conservation areas, and ocean cleaning to improve users' interactive experience (Huang et al., 2022). Ant Forest also won the highest award of the United Nations' annual environmental protection action, the Champion of the Earth Award in 2019 (Rukikaire, 2019).

In summary, Alipay's Ant Forest game module integrates PEBs with gamification and represents an innovation of the mobile Internet. Online gamified virtual rewards record carbon footprint, and, in conjunction with offline physical rewards, users' PEB can also be enhanced through socialisation. Reducing carbon emissions to promote ecological development is an important measure conducive to the sustainable development of mankind. Therefore, applying the gamification elements in mobile applications to achieve the sustainable development goals (SDGs), especially in protecting, restoring, and promoting sustainable use of terrestrial ecosystems, sustainably managing forests, combating desertification, preventing and reversing land degradation, and preventing biodiversity loss (SDG Goal 15) is clearly a meaningful attempt (Li & Peng, 2019). The interface screenshots in Figure 1.1 show the energy points, virtual trees, supported PEBs, and browsing of the planting environment of Ant Forest.

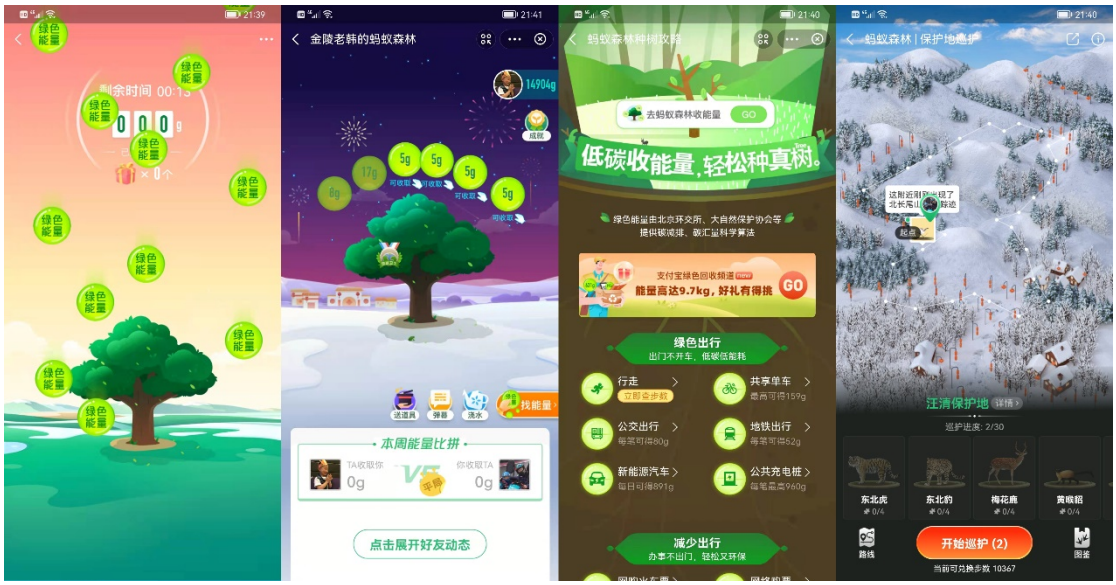

Figure 1.1 Ant Forest Mobile Application Interface

Source: Screenshots from the researcher's mobile application

1.3 Problem Statement

Over the course of history, human behaviour towards nature has changed from protecting against threats to the natural environment to overexploitation of natural resources, which has caused environmental pollution and climate change (Bargaoui & Nouri, 2021). Although psychological researchers have paid attention to the impact of behavioural changes on coping with environmental degradation, the priority given to psychological theories has led to a systematic omission of some particularly influential determinants (Nielsen et al., 2021). For example, studies that applied the Knowledge Attitude and Practice (KAP) measurement standard, a common psychological model in environmental behaviour research, showed converging results (Panyagometh et al., 2023; Wang & Zhang, 2021; Wang & Ma, 2019). Past studies using the Theory of Planned Behaviour (TPB) and Theory of Reasoned Action (TRA) also showed a similar situation, that is, some core variables may not show significant effects under certain circumstances (Yadav et al., 2022; Sok et al., 2021; Asih et al., 2020).

The pollution brought by industrial development and the continuously growing population have put tremendous pressure on the world's environment. The major ecosystems that are affected by pollution include soil, water, and air (Khan & Chang, 2018). In the past four decades, the widespread use of fossil fuels in China has led to high greenhouse gas emissions and climate change (Xu et al., 2021). China has set a sustainable development goal of achieving carbon neutrality by 2060; reducing carbon emissions is undoubtedly a challenge (Xu et al., 2021).

The rapid increase in water demand from surging populations, irregular climate changes, and unbalanced rainfall have brought issues of water shortage and pollution to many countries (Saladini et al., 2018). The spatial distribution of water resources in China is uneven, and many regions are facing critical water shortage issues. For instance, Heilongjiang and Jilin in northeast China are affected with high water shortage risks (Cao et al., 2019). Water shortage has led to the desertification of arable lands, which is compounded by unscientific farming methods, overgrazing, improper waste disposal, and the impact of climate change, making these issues more serious (Khan & Chang, 2018).

The typical desertification areas in China are concentrated in three regions of northwest, north, and northeast China. Sandstorms and pasture degradation in these areas have resulted in economic losses of up to 4.5 billion Chinese Yuan (CNY) (Han et al., 2020). Environmental pollution and desertification have led to a decline in China's industrial and food production capacities, coupled with the shortage of water resources—these issues have critically threatened the lives of the Chinese people (Khan & Chang, 2018).

China's serious haze pollution has also aroused wide public concern (Zhou et al., 2019). According to the Report on the State of the Environment in China (2018), among 338 cities in China, the air quality in 217 cities (64.2%) exceeded the environmental air quality standards (Zhang et al., 2020b). Haze pollution has seriously threatened the health of the Chinese public and the development of the national economy (Yin et al., 2020).

With all these ongoing issues, the PEB of the Chinese public has gradually showed improvement. However, the effects of social systems on the interaction between environmental awareness and PEB have remained underexplored (Yang et al., 2020a). Cleveland et al. (2020) claimed the potential influence of individuals' responsibility and ability for environmental protection on their PEB. Nonetheless, several prior studies identified a gap in the relationship between environmental awareness and behaviour, and that the level of environmental awareness is greater than that of PEB, implying that environmental awareness does not necessarily translate into PEB (Fu et al., 2020). This may be due to a misunderstanding of the concept of environmental awareness (Yang et al., 2020a). There is no consensus on the most effective way of translating environmental knowledge to PEB. Therefore, the way to make dwelling and professional environmental knowledge jointly affect PEB is an area worthy of attention (Duan & Sheng, 2018). It can be seen that the effective awakening of one's environmental awareness can be the key to addressing the highlighted issues.

Due to the existence of a large number of recycling activities by private institutions and individuals, China is unable to compile detailed statistics on the proportion of solid waste recycled (Guo et al., 2021). In order to effectively recycle urban solid waste, China selected eight cities, including Beijing, Shanghai, Guangzhou,

Shenzhen, Hangzhou, Nanjing, Xiamen and Guilin, as the first batch of pilot cities for garbage sorting, but this did not receive the active cooperation of all residents (Wu et al., 2021). As the city in China with the strictest enforcement of garbage sorting, Shanghai has effectively sorted 83.62% of household kitchen waste, but it has also created new problems such as low metal recovery rate and high chloride content (Wang et al., 2021).Meanwhile, video games stand out among many "awaken" methods due to their advantages in visual performance, content expression, and interactive function. Designers use visual elements and storytelling to influence consumers' pro-environmental consumption (Degirmenci, 2023; Quach et al., 2022; Ouariachi et al., 2020; Lee, 2019). There have been a few case studies on the application of interactive games in public education for environmental consumption, but related findings have remained lacking (Morris et al., 2019; McGonigal, 2016). Furthermore, studies on the relationship between environmental storytelling skills and PEB (Lee & Lee, 2020), as well as game content and interactive technologies related to environmental protection have remained scarce.

Prior studies on digital games often identified reward as one of the influencing factors, but there are not many in-depth studies on its influence. Badges, points, and trophies are the most common game reward mechanisms used (Whittaker et al., 2021). Studies have observed positive feedback through the use of points as reward, as it attracts players to advance in the game and motivate them (Yang et al., 2021a). The use of badges is also effective, as it allows players to record achievements in the information systems (Eliyas & Ranjana, 2022). Cavusoglu et al. (2021) also shared similar views and pointed out that badges can encourage users to contribute more in the online communities. However, Johnson et al. (2017) pointed out the lack of evidence on the significance of points and badges as gamified rewards. Badges and trophies, as virtual

rewards in the game, record users' cumulative performance, allowing then to observe their progress and achievements (Xu et al., 2021). At the same time, as these rewards display users' professional knowledge or outstanding performance, users are motivated to gain the recognition of others (Mahmud et al., 2020). Nevertheless, these effects have not been measured in depth (Whittaker et al., 2021).

Focusing on game production, Linderoth and Sjöblom (2019) showed the need for personnel with dual-abilities of education and game development for the design of serious games in order to achieve the desired design effect. On the other hand, when it comes to the game development process, the final released version is often markedly different from the previous design version. The modification of many game features requires developers to have strong planning and management capabilities (Landoni et al., 2020). The above viewpoints undoubtedly put forward higher requirements for developers (Hertzum, 2022). Game products also need to obtain marketing and testing feedback on user experiences during the game development process (Hertzum, 2022). When the game content deviates from players' expectations, user experiences are negatively affected (Geradin & Huijts, 2023; Rani & Saini, 2020). Due to the lack of business model applications in game development, project development cannot maintain clear indicators and measurements, which may lead to instability in the development process (Kasurinen et al., 2017).

Since gamification stimulates the flow state, which is deeply involved in the information system, the perceived persuasiveness can affect the application of the system in encouraging PEB (Shevchuk et al., 2019). However, the solution of adding different types of persuasive information into the gamification environment, especially the solution that is combined with the gamification mechanism, is often overlooked

(Böckle & Yeboah-Antwi, 2019). Although certain gamification elements have been used to improve the overall user engagement, these effects are often mixed (Böckle et al., 2018), and their utility mechanism is not clear. In addition, within the context of persuasive technology, competition in the social environment can internally motivate users to perform target behaviours, but only a few prior studies explored the persuasiveness of competition as a predictor of incentive strategies (Orji et al., 2019a). Despite the recognition of gamification and persuasion technology as a concept of human-computer interaction (HCI) in the research community (Martin & Kwaku, 2019), the important underlying mechanisms and personalised solutions of these systems have not been fully studied (Schöbel et al., 2021; Seo et al., 2021; Martin & Kwaku, 2019).

Studies have also explored issues of environmental awareness and motivation, especially on ways to stimulate and maintain PEB. Du et al. (2018) proved the existence of an "awareness-behaviour gap" when PEB takes place and the slight impact of environmental awareness on PEB in certain times. In the case of environmental motivation, Ling and Xu (2021) claimed that the use of financial incentives in the process of implementing environmental policies can cause "motivation crowding out"'; the more time it takes, the more difficult it is to eliminate the crowding effect. Therefore, using financial incentives to induce PEB can reduce environmental motivation (Ling & Xu, 2021).

Considering the environmental challenges of China and the academic discourse in the identified gaps in research, the current study conducted an in-depth investigation on the influence of gamification elements on PEB through environmental awareness and motivation. In view of the above, this study aimed to examine the influence of

reward-based gamification on the PEB of Ant Forest users and obtain an in-depth understanding of the effect process.

1.4 Research Questions

Based on the discussion of the problem statement above, this study raised the following research questions:

1. How does reward affect perceived persuasiveness and user's pro-environmental behaviour in Ant Forest?
2. How does perceived persuasiveness affect user's pro-environmental behaviour in Ant Forest?
3. How do user's environmental awareness and motivation moderate the relationship between perceived persuasiveness and user's pro-environmental behaviour in Ant Forest?
4. Could a reward-based gamified environmental application model be proposed?

1.5 Research Objectives

Corresponding to the above research questions, the research objectives of this study were determined as follows:

1. To analyse the effect of reward on perceived persuasiveness and user's pro-environmental behaviour in Ant Forest.
2. To analyse the effect of perceived persuasiveness on user's pro-environmental behaviour in Ant Forest.

3. To examine the moderating effects of user's environmental awareness and motivation on the relationship between perceived persuasiveness and user's pro-environmental behaviour in Ant Forest.

4. To propose a reward-based gamified environmental application model.

1.6 Study Significance

The current study presented four key aspects of significance. Firstly, in terms of theoretical significance, this study developed a framework based on the Stimulus-Organism-Response (S-O-R) theory (Mehrabian & Russell, 1974), which served as an overarching theoretical foundation. This study also introduced perceived persuasiveness as an organism factor for the expansion of the theory based on reward-based gamification. Visual content and text information have been proven to produce persuasive effects on users (Liu et al., 2019a; Heinbach et al., 2018). Perceived persuasiveness, as an approximation of the actual persuasive effect on the users of persuasive information systems (Thomas et al., 2019), can be a good measure of the emotional effect of gamification. This approach establishes a more explicit evaluation standard for the persuasive effect of reward-based gamification (Orji et al., 2019; 2017).

Secondly, in terms of academic significance, this study validated the positive contribution of gamification in the field of environmental communication. Gamification has been proven to communicate social and environmental issues (Maltseva et al., 2019). It has become an important tool for participatory environmental communication (Chen & Cai, 2019). Gamification mechanisms train, evaluate, and improve users' desires to communicate environmental crises to others without bringing risks to the participants (Cavalcanti et al., 2021). In addition, gamification simplifies and highlights complex

sustainability issues as a highly innovative environmental communication tool, making them easily understood by users (Fjællingsdal & Klöckner, 2020). Furthermore, the integration of gamification design and environmental interpretation bridges the psychological distance between users and environmental protection areas; thus, strengthening users' environmental perception (Fernández-Ruano et al., 2022).

Thirdly, in terms of social significance, this study would benefit the Chinese government and enterprises. The government and enterprises can develop more interesting green and low-carbon projects, add gamification content to spread green and low-carbon knowledge, and provide the public with a means of direct participation (Zhang et al., 2020c). Government policies and green financial technology represented by Alipay have achieved positive results in environmental protection (such as reduction in carbon emissions, promotion of green consumption, and afforestation) (Muganyi et al., 2021). As for enterprises in application development, the addition of elements like rewards, real-time images, and friend interaction to the information system can better increase users' sense of accomplishment and entertainment, thereby enhancing their intention to continuously use the system (Yang et al., 2018).

Furthermore, the reward element in gamification needs to be better recognised. According to the behavioural theory, one's motivation depends on the type and frequency of rewards (tangible or intangible) (Smeddinck et al., 2019). In the case of ordinary applications, gamified reward elements mainly include badges, leaderboards, and scores. External incentives have minimal effects on users with strong internal motivations (Tóth & Lógó, 2018). As for environmental protection applications, rewards are not a condition that must be met, but rewards that can provide users with

surprises can effectively improve their satisfaction with the application and motivate them to participate more (Wang & Yao, 2020).

Last but not least, in terms of practical significance, this study demonstrated its novelty through the mixed-methods application for both application users and developers. A new model was proposed to encourage application developers to understand the impact of their development results on users more intuitively. Developers of environmental games can make use of the proposed model in the development process, ensuring the effectiveness of the features they design (Whittaker et al., 2021). In-depth research on gamification can provide application developers with more information, enabling them to have a deeper understanding of users' awareness, motivation, and behaviours for participating in collaboration, competition, and pursuit of goals.

Correspondingly, this study would improve personalised user experiences in application development (Luther et al., 2020; Noorbehbahani et al., 2019). This particular outcome is evident in learning, where mobile interaction methods are used to develop systems that engage learners in different learning environments (Jie & Sunze, 2023; Bernacki et al., 2020; Suartama et al., 2019), leading to better application development that learns and adapts to users. Developers add gamification to meet users' hedonic expectations in information systems and bring additional motivation for participation to users (Seidler et al., 2020; Oluwajana et al., 2019).

Overall, the research and practice of gamification can not only better stimulate human motivation and promote various behaviours, including PEB, but also help developers to build better information systems that can provide better user experiences.

The current study propelled the significant need for more research on the development of design guidelines.

1.7 Study Scope

This study focused on testing the direct effects of reward in gamification on perceived persuasiveness and user's PEB, the direct effect of perceived persuasiveness on user's PEB, and the moderating effects of environmental awareness and motivation on this process. A theoretical framework was first established based on the review of literature to discern the potential connections between various constructs within the context of Ant Forest. Following that, the effects of reward elements in gamification, perceived persuasiveness, environmental awareness and motivation, and PEB were explored.

Methodologically, the explanatory sequential mixed methods (ESMM) design was employed in this study (Wipulanusat et al., 2020). Firstly, 621 respondents were selected for this study's online survey (quantitative method). Following that, 12 participants were selected for this study's face-to-face interview sessions (qualitative method). Their viewpoints on the obtained quantitative results were recorded. This mixed-methods approach yields diverse data and minimises the errors caused by using a single method (Creswell, 2014). The advantages of quantitative and qualitative methods complement each other, and researchers can also better grasp the truth and details of the facts (Elmas et al., 2019). All questionnaire surveys and interviews received authorisation from the research subjects. The privacy of their personal details and relevant information were also ensured. In addition, IBM SPSS, SmartPLS, and MAXQDA were used for data analysis. The final results were released through a joint display (Bustamante, 2019).

1.8 Concept Definitions

This section includes the processes of defining, theorising, refining, and specifying the meanings of abstract concepts for the constructs under study. It is a procedure in which imprecise concepts are given more specific and exact meanings for the study (Rubin & Babbie, 2017). The key concepts in this study are defined as follows:

1.8.1 Gamification

Deterding et al. (2011) defined gamification as "the use of game design elements in non-game contexts." On this basis, Hamari et al. (2014) proposed that gamification can be expressed in motivational affordances, psychological outcomes, and behavioural outcomes. In this study, gamification is defined as "the use of game design elements in non-game contexts," following definition of Deterding et al. (2011).

1.8.2 Reward

Phillips et al. (2013) proposed the following definition of reward elements in gamification: a positive return that serves to reinforce player behaviour within a game. In this case, rewards specifically refer to things that can be measured in games, whereas activities that are considered "rewards" but without returns in daily life are not included (e.g., the fun of playing games) (Phillips et al., 2013). In this study, reward is defined as "a positive return that serves to reinforce player behaviour within a game," following definition of Phillips et al. (2013).

1.8.3 Perceived Persuasiveness

Thomas et al. (2019) defined perceived persuasiveness as an approximate measure of the effectiveness of an intervention. Meanwhile, Lehto et al. (2012) defined

perceived persuasiveness as “the integration of the individual’s subjective evaluation of the system and its impact on the self,” which was applied in the current study. In this study, perceived persuasiveness is defined as “the integration of the individual’s subjective evaluation of the system and its impact on the self,” following the definition of Lehto et al. (2012).

1.8.4 Environmental Awareness

Cui et al. (2015) defined environmental awareness as an emotional attitude towards the environment and environmental values, which guides people to respect, care about, and treat the environment from the perspectives of emotions and ideas. Meanwhile, Morrison et al. (2015) proposed the definition of environmental awareness as the perception and understanding of the entire environment and related issues. As for the current study, Cui et al.’s (2015) definition of environmental awareness was applied.

1.8.5 Environmental Motivation

Ling and Xu (2021) defined environmental motivation as the PEB-driven motivation by other pro-social preferences, such as intrinsic pleasure, mutual benefit, and moral commitment. Environmental motivation is a particular type of motivation formed under the external stimulus of environmental degradation and acquired cognitive improvement (Geng et al., 2017). It relies more on people’s initiatives to reduce or even abandon environmental damage, and it is conducive to the implementation of PEB (Geng et al., 2017). As for the current study, environmental motivation was conceptualised as “the motivation driven by pro-social preferences to implement PEB” based on the definitions proposed by Ling and Xu (2021) and Geng et al. (2017).

1.8.6 Pro-Environmental Behaviour

Pro-environmental behaviour (PEB) is defined as a series of pro-social behaviour that promotes the health and well-being of the natural environment and other people (or species) (Schmitt et al., 2018). According to Lange and Dewitte (2019), PEB includes performing actions that are beneficial to the natural environment and avoid damage to the natural environment. Schmitt et al.'s (2018) definition of PEB was applied in the current study.

1.9 Study Structure

This thesis is divided into six chapters. **Chapter 2** reviews relevant literature on environmental issues around the world, persuasive technology, environmental game companies, Ant Forest, and the selected constructs under study. Research gaps, the theoretical framework, and the corresponding hypotheses are presented at the end of this chapter.

Chapter 3 clarifies the explanatory sequential mixed methods design used in this study, which included both online survey (Phase 1) and interview (Phase 2) methods. This chapter also describes and justifies the study's instrument, sample population, operationalisation, data collection procedure, and the considered statistical analysis techniques. In addition, this chapter discusses the ethical issues considered.

Next, **Chapter 4** presents the obtained quantitative results from the online survey and summarises the quantitative conclusions in regards to the theoretical framework, which achieves the goal of Phase 1. Subsequently, the qualitative findings from the in-depth interviews (Phase 2) are presented in **Chapter 5**. The qualitative results contain all explanations for the quantitative results and are integrated and

interpreted with the quantitative results through the side-by-side joint display at the end of the chapter.

Chapter 6 discusses the key results and findings with respect to the study's objectives. All the achievement of objectives are summarised in this chapter, along with the study's implications and contributions. The limitations of the study and recommendations for future research are presented at the end of this chapter.

1.10 Summary

Overall, this chapter highlighted the environmental issues in China, the status of Ant Forest in promoting PEB, and the lack of studies in the domains of interest. This chapter also outlined the study's objectives and research questions, as well as the significance and scope of the study. The definitions of the relevant concepts were also provided. The next chapter focuses on the literature review and the theoretical framework of the study.

CHAPTER 2

LITERATURE REVIEW AND THEORETICAL FRAMEWORK

2.1 Introduction

This chapter reviews literature on environmental issues around the world, environmental game companies, Ant Forest, persuasive technology, and the selected constructs under study. Additionally, this chapter outlines the gaps in research and describes the development of a theoretical framework and the corresponding hypotheses.

2.2 Global Environmental Issues

Climate change is the most critical global environmental issue (Mikhaylov et al., 2020). Back in 2015, 195 countries signed the Paris Convention, which serves as the first global climate agreement that clearly states that all mankind must effectively and progressively address climate change (United Nations, 2015). Climate change caused by urbanisation, industrialisation, and greenhouse gas emissions from residential areas destroys the natural environment and threatens life on land, water, and air (Celik, 2020). With the migration of people to avoid disasters, this has led to the spread of climate change regions as well (Celik, 2020).

The effects of climate change on the exposed organisms and people include, but are not limited to, heat waves, droughts, floods, tornadoes, fires, desertification, and the disappearance of forests and glaciers—all of which ultimately lead to human survival crisis (Cianconi, 2020). In specific cases of South Africa, climate change has caused

droughts, reduced rainfall, and increased temperatures, which have caused the water levels of rivers and wells to drop and seriously affected the community's water supply (Rankoana, 2020). Another example is Brazil; the deforestation rate in the Amazon rainforest increased by 34.1% between 2018 and 2019 (Conceição et al., 2020). These original rainforest areas were replaced by pastures and farmland, leading to the disappearance of forest barriers, and the country observed an increase in air pollution by 1994.30 tons of fine particulate matters due to fires every year (Conceição et al., 2020).

Secondly, the unreasonable use of energy is also one of the most serious global environmental issues (Lu et al., 2020). As an indispensable support for society, energy supports the continuous development of the economy, from households to industries and from production to transportation (Cantarero, 2020). The principles of future energy contribute profound impact on the economy, society, environment, and public health (Azam et al., 2019). However, the production and use of energy affect the quality of the environment. For example, a study in Texas in the United States reported that oil and gas extraction can affect the reproductive health of nearby residents (Willis et al., 2021). Salahuddin et al. (2018) demonstrated, through a survey in Kuwait, that tourism investment, financial development, and energy consumption aggravate carbon emissions in both short and long terms. In another study, Shindell and Smith (2019) proved that the use of fossil fuels as energy sources can cause significant increase in air pollutants and greenhouse gas emissions, which affect air quality and climate.

According to Muhammad (2019), the economic growth of developed countries and the Middle East and North Africa (MENA) countries is positively correlated with CO_2, while the opposite is true for emerging countries and underdeveloped countries.

Additionally, the rapid use of land has caused global environmental issues (Chen et al., 2020). The process of urbanisation has led to the expansion of construction land and the rapid transformation of land use, bringing rapid economic growth, but also a series of environmental issues (Long & Qu, 2018). With the acceleration of urbanisation, a large number of abandoned industrial resources have been left in rural areas, which makes the ecological status of rural areas highly fragile, and often do not have the conditions for scientific governance and ecological restoration (Ding & Zhang, 2020). In a survey at the northern coast of Central Java, Indonesia, improper use of land was found to contribute significant flood exposure in the city and surrounding areas (Handayani et al., 2020). It can be seen that the erosion of cultivated land in the process of urbanisation has destroyed ecologically sensitive areas and contributed negative impact on food production and economic development (Abass et al., 2018).

Finally, water quantity and quality are another global environmental issues that cannot be overlooked (Holzer et al., 2020). The continuous rise of the global average temperature causes serious consequences for the natural environment in the form of deterioration in the quality of water resources (Tehreem et al., 2020). Scircle et al. (2020) pointed out that microplastic pollution generated by human industrial production enter coastal areas through rivers and accumulates in seafood, seriously threatening food

safety in the United States. The case of Lake Ziway in Africa also reflects a similar scenario—drinking water and aquatic biological indicators record far below normal standard values and are clearly contaminated with heavy metals, pesticide residues, and eutrophication (Merga et al., 2020). Coastal waters have experienced gradual warming, acidification, and deoxygenation, and harmful algal blooms (HAB) have seriously threatened public health, aquaculture, tourism, and ecosystems (Gobler, 2020).

Overall, environmental pollution caused by poor waste management is an important cause of global environmental problems, including direct interactions with air, soil and water pollution, marine debris, and hazardous wastes (Ferronato & Torretta, 2019). To address these issues, it is imperative that governments formulate long-term development policies with strict accountability for resources and regulations (Abbass et al., 2022). The researchers have statistically demonstrated the role of information and communication technology in addressing environmental degradation, which provides a solid basis for decision makers to formulate policy frameworks for sustainable development (Chien et al., 2021a). Emerging paradigms such as the Internet of Things (IoT), cloud computing, opportunity sensing, mobile crowdsourcing, and crowdsourcing based on mobile Internet technologies can make positive contributions to the advancement of global environmental protection projects (Elazhary, 2019).

2.3 Environmental Issues in Asia

The performance of Asian countries in the Environmental Performance Index (EPI) is not optimistic (Hou et al., 2019). The relatively low overall score and a large

gap in the national index (Wendling et al., 2020) imply that the environmental protection development of these countries is highly uneven. Many Asian countries undergo an economic transition from a GDP[3]-based economy to a sustainable one (Choi, 2019). Both governments and enterprises expect to promote better life quality, but environmental policies are often in question due to the lack of effective management (Choi, 2019).

Statistics revealed that 1.24 million people in India died of air pollution due to environmental particulate matters and household solid fuels in 2017, accounting for 12.5% of the country's total deaths (Balakrishnan et al., 2019). Hashizume et al. (2020) conducted a systematic review of dust exposure in Asia and observed a positive link between the mortality rate and the number of hospitalisations related to the circulatory and respiratory systems in various countries. In general, the decline in air quality triggers a large-scale public environmental crisis, which is a major issue that all countries have to address.

The issue of climate change is also prominent in Asia. The middle and high latitudes of Asia display one of the strongest climate change trends in the world and are also the most sensitive ecosystems, making vegetation and other related elements highly susceptible to climate change (Wei et al., 2023; Zhao et al., 2022b; Choi et al., 2019). Park et al. (2018) systematically reviewed cases of the three most important river

[3] GDP is the abbreviation for Gross Domestic Product