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Fueling Pro-Environmental Behaviors with Gamification Design: Identifying Key Elements in Ant Forest with the Kano Model

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Abstract: As emerging approaches, IT-based applications designed for encouraging pro-environmental behaviors have shown great potential. By focusing on Ant Forest, this study attempts to explore the embedded gamification design to identify key elements that lead to users' long-term game participation which eventually fosters pro-environmental behaviors. First, a focus group interview was conducted to identify twenty-one gamification design elements in four modules: task design, social interaction, feedback, and reward. Furthermore, this study employed the Two-Dimensional Kano Model and better–worse analysis to classify and prioritize the gamification design elements that impact users' attitudes toward Ant Forest. Five Attractive elements, five One-Dimensional elements, four Must-Be elements, and seven Indifferent elements were identified in Ant Forest from 207 questionnaires. The results emphasize the significant impact of gamification design elements that are highly correlated with environmental sustainability (i.e., green context, pro-environmental behaviors, plant a tree) in Ant Forest. In addition, users who are rewarded by both virtual medals and official certificates demonstrate higher satisfaction, whereas elements associated with social interaction and competition show trivial importance. This study has profound theoretical implications as an interdisciplinary study, and yields helpful insights for practice to improve Ant Forest design, promote Ant Forest usage and finally fuel pro-environmental behaviors.

Keywords: pro-environmental behavior; gamification; game design elements; kano model; ant forest

1. Introduction

Facilitating sustainable development has been a worldwide consensus for dealing with the upgrading environmental challenges, aiming to harmonize the economic growth and environment protection [1,2]. A variety of environmental issues pose a threat to environmental sustainability, among which deforestation, global warming, and air pollution are all rooted in improper human activities [3]. To address these worldwide pollution issues, it is imperative to strengthen the awareness of environmental sustainability [4] as well as facilitate behavioral changes [5]. However, it is worth noting that an outstanding awareness–behavior gap exists in this area [6]. People claim that they are concerned with sustainability but often fail to transform this concern into their daily behavior. Therefore, it is important to investigate efficient approaches to fill the awareness–behavior gap and foster people's real pro-environmental behaviors.

Gamification, infusing game design elements into non-game contexts [7], has been widely used in various contexts to facilitate users' engagement and motivation [8], yet is still scant in the environmental area [9,10]. Ant Forest, a gamified green initiative implemented by Internet technology in China, has been awarded the United Nations' Champion of the Earth Award in 2019 as a good practice system for

facilitating pro-environmental behaviors [11]. Through delicate virtual gamification design, this new approach successfully links people's environmental awareness to low-carbon behaviors in the real world [12].

As an affiliation of Alipay, Ant Forest was launched in 2016, where a personal carbon account platform was built for collecting and sharing green energy saved through low-carbon lives [13]. Specifically, each user can obtain a certain amount of green energy by recording 24 types of daily pro-environmental behaviors including walking, shared bicycle riding, mobile payments, public transportation commuting, second-hand goods recycling and so on. Also, as a gamified social program, users can "give" green energy to friends, "steal" green energy from friends, as well as "co-plant" trees with friends. When a user's green energy accumulates to a certain amount, he or she can select a sapling to plant a grown-up virtual tree, which will turn into a real tree in deserts by Ant Forest. This information technology-based platform enables people to record low carbon footprints, engage in low-carbon behaviors, and gradually cultivate green lifestyles [14]. By the end of 2019, 500 million Ant Forest users had reduced more than 7.92 million tons of carbon emission, which was converted to 122 million real trees planted in deserts of more than 66,667 hectares [15].

Although Ant Forest has reached early success, its lasting success depends on users' continuous involvement and the ultimate purpose is to facilitate their pro-environmental behaviors. Therefore, it is crucial to explore the embedded gamification design to identify key elements that lead to users' long-term game participation which eventually fosters green behaviors. A substantial amount of research has focused on new ways to advocate green lifestyles, such as green food purchasing [16], green building initiatives [17] and so on. The Ant Forest platform, as an innovative and effective approach to promote pro-environmental behavior, has rarely been studied in the current literature thus far. To address these concerns, this exploratory research seeks to answer two research questions:

- (1) What are the important gamification design elements to users in Ant Forest?
- (2) How do these elements impact users' attitudes towards Ant Forest?

Drawing on the relevant literature, we employ the Kano Model, a widely used method for evaluating the design quality of products or services, to answer these research questions. Based on the definition proposed by Koster [18], a focus group interview was first conducted to identify gamification design elements in Ant Forest, after which task design, social interaction, feedback and rewards are proposed as four modules that consist of twenty-one gamification design elements in Ant Forest. Furthermore, although Ant Forest has achieved great success now, its long-term success cannot be guaranteed without a delicate investigation into the attractiveness, importance, and necessity of different gamification design elements. We employ the non-linear two-dimensional Kano Model to classify and prioritize the gamification design factors based on how they affect user satisfaction or dissatisfaction under different levels of fulfillment in Ant Forest [19].

The data of 207 valid questionnaires help us to distinguish the gamification design elements into Attractive, One-Dimensional, Must-Be, and Indifferent categories. Furthermore, a better–worse analysis [20] was also conducted. Five Attractive elements, five One-Dimensional elements, four Must-Be elements, and seven Indifferent elements were identified in Ant Forest. As an interdisciplinary research, this study has profound theoretical implications in relevant fields, including sustainable development, environmental protection, gamification design, and mobile applications. The findings of this study also yield helpful insights for practice to improve Ant Forest design, promote Ant Forest usage and finally fuel pro-environmental behaviors.

The rest of this paper is organized as follows. Section 2 reviews the relevant literature and theory. Section 3 describes our research methodology and data collection. Section 4 explains the results of our Kano Model. Section 5 summarizes the findings and discusses the implications and limitations of this study.

2. Theoretical Background

2.1. IT-Enabled Pro-Environmental Behavior

Pro-environmental behavior, also named “ecological behavior”, “environmentally friendly behavior”, or “environmentally sustainable behavior”, refers to a range of behaviors that benefits the environment, such as afforestation, recycling, energy conservation, pollution reduction and so on [21,22]. Kollmuss and Agyeman [23] defined pro-environmental behavior as the sort of behavior that intentionally minimizes the negative impact that an action can have on the environment. Stern et al. [24] stated that individuals perceive an obligation for pro-environmental behavior when they believe their actions can help protect the environment. Hunter et al. [25] classified pro-environmental behavior into public (i.e., afforestation) and private (i.e., recycling) pro-environmental behaviors. In this research, we summarize and define pro-environmental behavior as “a range of voluntary personal behaviors that benefit the environment”.

With the development of information technology, pro-environmental behavior has seen a burgeoning revolution. On one hand, information technology extends the concept of pro-environmental behavior and shapes new routines for people [13]. Novel green lifestyle, such as mobile payment, shared bicycles, and electronic receipts cannot be implemented without information technology as their “enabler”. On the other hand, information technology works as an “accelerator” in promoting pro-environmental behavior. Tim et al. [26] have demonstrated the vital role of social media in environmental sustainability. At the firm level, green information systems were found to be effective in changing employees’ ecologically responsible behaviors [27]. Oppong-Tawiah et al. [10] have designed a gamified mobile application to encourage sustainable energy use in the office.

Alipay and its embedded Ant Forest, an information technology-based mobile platform, plays the roles of both “enabler” and “accelerator” of pro-environmental behavior. As a third-party payment application, Alipay enables a range of low-carbon behaviors that are connected with mobile payment, such as public transportation taking and online ticketing. Meanwhile, Alipay accelerates the habit of a green lifestyle by promoting pro-environmental behaviors in the form of a game, Ant Forest [12]. By recording personal low-carbon behaviors implemented through Alipay, users’ awareness of environmental protection is unconsciously motivated, and will finally be awarded by planting a real tree through Ant Forest. In a word, this innovative IT-enabled platform has demonstrated its power in the pursuit of environmental sustainability, and needs further investigation into to how it works, why it succeeds, and how to promote pro-environmental behavior through similar information technology.

2.2. Gamification Design

Gamification, “the use of game design elements in non-game contexts” [28], has been a hot trend recently. The main idea is to implement the “building blocks” of games into real-world contexts, so as to facilitate specific behaviors in the gamified context [29]. In the past ten years, gamification has seen wide adoption in education, training, marketing, human resources, and healthcare fields, which builds a new paradigm for enhancing brand awareness and loyalty, user participation and engagement [30].

The benefits of gamification are obtained through a delicate design of gamification elements [31,32]. Sailer et al. [29] summarized the elements that could be easily implemented by game designers: meaningful stories, avatars, teammates, leaderboards, points, performance graphs, and badges. Robinson and Bellotti [33] proposed a classification of gamification design elements, including general framing and general rules, resources and constraints, social features, feedback and status information, and incentives. Miller et al. [34] argued that social engagement, challenges and quests, leaderboards, points and levels, and badges are the most commonly used gamification design elements. Liu et al. [35] demonstrated seven gamification design elements: victory conditions, social networks, rankings, challenges, status, medals and rewards. According to Koster’s definition [18], a gamified product is defined by rules, interactivity, and feedback, and results in an incentive outcome; thus, we classify the gamification design elements into four modules, as illustrated in Table 1.

Table 1. Classification of gamification design elements.

Modules	Design Elements	References
Task Design	meaningful stories	[29,33]
	general framing/general rules	[18,33]
	resources and constraints/victory conditions	[33,35]
Social Interactions	avatars	[29,36]
	teammates	[29,37]
	social networks/social features/social engagements/social interactivity	[18,33–35]
	leaderboards/rankings/challenges and quests	[29,34,35]
Feedback	points/levels/feedback	[18,29,34]
	performance graphs/status information	[29,33,38]
Reward	incentives	[18,33]
	badges/medals/rewards	[29,34,35]

Gamification has rarely been applied to the environmental protection contexts, with Ant Forest as an exception (see Figure 1). In addition, little research has investigated the mechanics of gamification design, particularly regarding the rationale for how best to apply gamification elements in pro-environmental contents. In this study, we attempt to explore how the gamification design elements implemented in Ant Forest engage people in pro-environmental behaviors.

Figure 1. Gamification design in pro-environmental contents.

2.3. Two-Dimensional Kano Model

Traditional research assumed a linear relationship between product design quality and user satisfaction [39]. However, the linear relationship might be erroneous for understanding product elements [40]. Based on the motivator-hygiene theory [41], Kano et al. [19] proposed a non-linear two-dimensional model to categorize and prioritize different product elements based on how they affect user satisfaction/dissatisfaction when available or not. The model divides product elements into

five categories (see Figure 2): (1) Attractive elements are neither demanded nor expected by users, which result in great satisfaction when available but do not lead to dissatisfaction when unavailable; (2) One-Dimensional elements are those for which better availability results in linear increase of user satisfaction and vice-versa; (3) Must-Be elements are the basic requirements of a product, which result in extreme user dissatisfaction when they are absent or unsatisfied. Meanwhile, because users regard Must-Be attributes as prerequisites, their satisfaction level will not increase even if these attributes are available; (4) Indifferent elements bring neither satisfaction nor dissatisfaction; (5) reverse elements cause more satisfaction when absent than when present [42,43].

Figure 2. Five categories of elements in the two-dimensional Kano Model. Source: Gustafsson [44].

The Two-Dimensional Kano Model is constructed through surveys, where a user questionnaire is comprised of a series of question pairs for each element of a product (i.e., each game design element of Ant Forest). The question pair contains a functional form question, which collects respondents' answers when a product has a certain element, and a dysfunctional form question, which collects respondents' answers when the product does not have the element. Each respondent has to answer regarding his or her perceived satisfaction for each element [20] (see more details in Section 3.2). An importance weighting of each gamification design element is also measured on a five-point Likert scale. Based on the survey results from all respondents, the final categorization of elements is figured out through a statistical analysis [43].

As an efficient tool for understanding user satisfaction, the Two-Dimensional Kano Model has been widely adopted in practice due to its convenience in categorizing product elements [19]. The Kano Model was originally designed for the service industry. Lee and Chen [45] used the Kano Model to measure and classify hotel service elements that have a non-linear relationship with consumer satisfaction. Materla et al. [40] implemented the Kano Model to understand the behavior of patients and their needs associated with the quality of healthcare service elements. Later, the Kano Model has also been applied in the User Interface and User Experience (UI/UX) fields due to its applicability in design science [46]. Mayer [47] used the Kano Model to identify attractive user interface software components in management support systems. Kuo [48] applied the Kano Model to examine elements in online communities that increase or decrease satisfaction. Overall, the Kano Model has been implemented

in both service and design industries, but there is a lack of research that provides insights into the environmental protection industry. Therefore, the Kano Model is an appropriate tool to investigate the UI/UX design in Ant Forest, which is a gamified application for promoting pro-environmental behavior.

3. Methodology

3.1. Identifying Gamification Design Elements in Ant Forest

The early success of Ant Forest could be largely attributed to its gamification design [14]. Based on the definition proposed by Koster [18], we classify the gamification design elements in Ant Forest into four modules: task design, social interaction, feedback and reward. Then, an initial draft of twenty-three gamification design elements in Ant Forest was formulated on the basis of Table 1. Thereafter, we conducted an iterative discussion process within a focus group that contained six volunteer students who frequently used Ant Forest in the past three months. The discussion process encouraged participants to verify whether all gamification design elements in Ant Forest are captured and clearly categorized. The focus group interview was stopped when no further modification was proposed. Finally, twenty-one gamification design elements are identified in Ant Forest, as shown in Table 2.

Table 2. Gamification modules and design elements in Ant Forest.

Gamification Modules	Gamification Elements	Descriptions
Task Design	task1	Ant Forest is based on a green context to benefit the public welfare.
	task2	The countdown reminder for collecting green energy.
	task3	Green energy comes from pro-environmental behaviors (i.e., walking, shared bicycle riding, mobile payment, and so on).
	task4	Users act as protagonists in Ant Forest.
	task5	Different species of saplings in Ant Forest are marked with different levels of difficulties, meaning that they require different amounts of green energy.
Social Interaction	inter1	Users can form teams to collaboratively plant trees in Ant Forest.
	inter2	Ant Forest enables users to communicate with their online friends.
	inter3	Ant Forest enables users to communicate with the service provider.
	inter4	There are competitions and rankings among online friends in Ant Forest.
	inter5	Online friends in Ant Forest are enabled to help with each other (i.e., watering their saplings, helping to collect green energy, and so on).
Feedback	fdbk1	Users can get real-time feedback on the green energy they generate every day.
	fdbk2	Demonstration of users' certificates instantly in Ant Forest after successfully planting trees.
	fdbk3	Users can get real-time feedback on the green energy given or stolen by online friends in Ant Forest (i.e., grams, time, etc.).
	fdbk4	Users can get real-time feedback on task completion in Ant Forest (i.e., how much green energy has been saved for saplings).
	fdbk5	Users can display the planted trees in the main interface of Ant Forest.
Reward	rewd1	Users can collect all their green energy by logging in time to prevent other friends from stealing it.
	rewd2	Users can steal green energy from their online friends by logging in time.
	rewd3	Users who plant three trees in one year can get the "National Voluntary Tree Planting Certificate" issued and stamped by an official organization in China.
	rewd4	Users can get corresponding digital badges when completing different tasks.
	rewd5	The virtual trees planted in Ant Forest will be turned into real trees planted in desertified areas as rewards for users.
	rewd6	If users fail to collect green energy in time, the energy will become invalid and disappear.

The task design module indicates the general background and rule settings in the game, including providing a background story, contextualizing the game behaviors, and setting game rules and goals [29,33]. Ant Forest is embedded in an environmental-friendly context which attaches specific meanings to pro-environmental behaviors. Users act as protagonists in Ant Forest, who can decide to plant different species of trees with distinct “green energy” values. The social interaction module includes gamification elements designed for enabling players to communicate, collaborate and compete with each other in the game [34,35]. For collaborative environmental endeavors, the involvement of a social process is supposed to be conducive to engaging participants in pro-environment behaviors [49]. The feedback module provides the status information of a user, including his or her points, levels, and visualized progress [18,33]. Users of Ant Forest can “see” the green energy collected through their pro-environmental efforts [12], which instills the environmental awareness to shape a green lifestyle. Finally, the reward module contains elements that are designed for encouraging players to engage in and complete the assigned tasks, such as badges, medals and certificates, as well as the designed punishments [29,34]. Ant Forest participants can receive an official certificate to acknowledge their contribution in planting a tree in the remote desert [50]. The incentive rewards are useful in promoting pro-environmental behaviors. In a word, the four modules which consist of twenty-one gamification design elements in Ant Forest are all contextualized to green initiatives with an aim to fuel pro-environmental behaviors.

3.2. Data Collection

In this study, we attempted to understand the importance, attractiveness, and necessity of each gamification design element under the environmental sustainability context; thus, the Two-Dimensional Kano Model was adopted. We first constructed the questionnaire based on the Kano method according to the gamification design elements in Ant Forest identified from our focus group interview. The questionnaire includes three parts: (1) Kano items, including a series of paired questions in both functional and dysfunctional forms for each identified gamification design element (see Table 3 for the example of one element); (2) an importance weighting of each gamification design element, which is measured on a five-point Likert scale; (3) additional questions about participants’ demographics, Internet usage experience, and familiarity with Ant Forest. The questionnaire was distributed through a popular web-based survey platform in China (www.wjx.cn).

Table 3. Functional and dysfunctional forms of Kano questions.

Gamification Design Elements	Kano Questions	Answers
Ant Forest is based on a green context to benefit the public welfare.	Functional Form: How do you feel if this element is present in Ant Forest?	1. I like it that way 2. It must be that way 3. I am neutral 4. I can live with it that way 5. I dislike it that way
	Dysfunctional Form: How do you feel if this element is NOT present in Ant Forest?	1. I like it that way 2. It must be that way 3. I am neutral 4. I can live with it that way 5. I dislike it that way

Through a convenience sampling method, we recruited participants from three public universities in China. The student sample is appropriate because it is reported that the major users of Ant Forest (38.8%) are less than 24 years old [51] and students count for the largest proportion of Chinese Internet users [52]. A total of 221 questionnaires were distributed online and the final sample included 207 valid questionnaires (i.e., the response rate is 93.6%). Table 4 reports the demographics of the final sample. Most participants are college students (77.8%) between 19 and 25 years of age (79.2%). In addition, the average Internet usage experience of our sample is 8.1 years and the average number of

planted trees in Ant Forest is 4.9, both of which indicate that participants are experienced in using the IT-enabled Ant Forest and, thus are qualified to provide their user experiences in the survey.

Table 4. Demographics of the final sample.

	Item	Frequency	Percent (%)
Sex	Male	89	43.0
	Female	118	57.0
Age	<18	8	3.9
	19–25	164	79.2
	26–30	27	13.0
	31–40	2	1.0
	41–50	6	2.9
Education	Junior college and below	2	1.0
	Bachelor	132	63.8
	Mater	56	27.1
	Ph.D. and above	17	8.2
Career	Institutional/Official servant/Government staff	19	9.2
	Service personnel	1	0.5
	Company staff	23	11.1
	Student	161	77.8
	Worker	3	1.4

4. Empirical Results

4.1. Kano Category for Gamification Design Elements in Ant Forest

As we described in Section 2.3, the gamification design elements in Ant Forest can be classified into one of the five categories based on the respondents' answers that combine both functional and dysfunctional question forms. The Kano evaluation table [20] clearly demonstrates the standards of classification in the Two-Dimensional Kano Model (see Table 5). Apart from the Attractive element (A), One-Dimensional element (O), Must-Be element (M), Indifferent element (I), and Reverse element (R), another element named "Questionable Answer" (Q) was also proposed to indicate confusing answers which are rarely seen in reality.

Table 5. Kano evaluation table.

Answer of the Functional Form	Answer of the Dysfunctional Form				
	1. I Like It That Way	2. It Must Be That Way	3. I Am Neutral	4. I Can Live with It That Way	5. I Dislike It That Way
1. I like it that way	Q	A	A	A	O
2. It must be that way	R	I	I	I	M
3. I am neutral	R	I	I	I	M
4. I can live with it that way	R	I	I	I	M
5. I dislike it that way	R	R	R	R	Q

Note: Attractive (A), One-Dimensional (O), Must-Be (M), Indifferent (I), Reverse (R), Questionable (Q).

For each element, the answers with the highest frequency percentage determine the Kano category it belongs to. In addition, following prior study [53], we incorporated a new category—Mixed (X) when the dominant distribution is absent. The Mixed category is created when the category strength

(i.e., the difference between the highest percentage and the second-highest percentage) is less than six percent, and the total strength (i.e., the total percentage of A, O, and M elements) is more than sixty percent [54].

Based on the standard procedure, the Kano categories for gamification design elements in Ant Forest were reported in Table 6. As Table 6 indicates, most of the gamification design elements in Ant Forest are not as important as we thought since they are categorized into Indifferent elements (I), suggesting that these elements show trivial influences on user satisfaction. Meanwhile, we found two One-Dimensional elements and three Mixed elements based on the participants' responses. For Mixed elements which cannot be clearly classified, we further identified their categories based on the "priority" order proposed by Matzler et al. [55]: $M > O > A > I$. Therefore, we found, altogether, one Attractive element and four One-Dimensional elements.

Table 6. Results of Kano category for gamification design elements in Ant Forest.

Gamification Modules	Gamification Elements	A	I	M	O	Q	R	Category Strength	Total Strength	Category
Task Design	task1	23.67	29.47	5.31	36.23	4.35	0.97	6.76	65.22	O
	task2	15.94	47.83	10.14	18.36	4.83	2.90	29.47	44.44	I
	task3	21.26	31.40	5.80	37.20	3.38	0.97	5.80	64.25	X (O, I) = O
	task4	21.26	43.96	6.76	23.19	2.90	1.93	20.77	51.21	I
	task5	26.57	45.89	7.25	15.46	3.38	1.45	19.32	49.28	I
Social Interaction	inter1	24.15	55.56	1.45	12.08	4.35	2.42	31.40	37.68	I
	inter2	16.91	50.24	7.25	18.36	3.86	3.38	31.88	42.51	I
	inter3	12.56	72.46	1.93	7.25	3.38	2.42	59.90	21.74	I
	inter4	20.77	48.79	8.21	15.46	3.38	3.38	28.02	44.44	I
	inter5	29.95	37.20	4.35	24.15	2.90	1.45	7.25	58.45	I
Feedback	fdbk1	17.87	38.16	11.11	26.57	4.35	1.93	11.59	55.56	I
	fdbk2	27.05	32.85	6.28	28.02	4.35	1.45	4.83	61.35	X (I, O) = O
	fdbk3	17.87	45.41	8.70	21.74	3.86	2.42	23.67	48.31	I
	fdbk4	24.64	37.68	9.18	23.19	3.86	1.45	13.04	57.00	I
	fdbk5	28.50	38.16	4.35	23.67	3.86	1.45	9.66	56.52	I
Reward	rewd1	18.36	41.55	9.66	24.64	3.86	1.93	16.91	52.66	I
	rewd2	27.54	36.71	6.76	20.77	3.38	4.83	9.18	55.07	I
	rewd3	38.65	33.33	3.86	19.81	3.38	0.97	5.31	62.32	X (A, I) = A
	rewd4	31.40	43.96	1.45	18.84	3.38	0.97	12.56	51.69	I
	rewd5	22.22	28.02	3.86	42.03	3.38	0.48	14.01	68.12	O
	rewd6	11.59	57.00	2.42	11.59	2.42	14.98	42.03	25.60	I

Note: the percentage of each category, category strength, and total strength are reported; Attractive (A), One-Dimensional (O), Must-Be (M), Indifferent (I), Reverse (R), Questionable (Q), Mixed (X).

The results show that all gamification design elements that are closely associated with environmental sustainability belong to the One-Dimensional elements (i.e., task1, task3, fdbk2, and rewd5). In other words, these four elements have a linear and positive relationship with user satisfaction in Ant Forest. For instance, based on a green context to benefit the public welfare (task1), Ant Forest motivates users to engage in pro-environmental behaviors to obtain green energy (task3), which would finally turn into a real tree planted in remote desert as a reward (rewd5), and be instantly displayed in Ant Forest (fdbk2). Meanwhile, users will be significantly dissatisfied with Ant Forest if these elements are absent. In addition, rewd3 is categorized as an Attractive element in Ant Forest, indicating that it provides a surprise to users when it is included but does not cause dissatisfaction if absent [43]. The result confirms the inestimable value of an official certificate in shortening the distance between virtual and reality by acknowledging the user's contribution in Ant Forest (rewd3) [12,50]. Other gamification design elements are all Indifferent elements which do not bring either satisfaction or dissatisfaction [42].

4.2. Better–Worse Analysis

Despite the simplicity of determining the Kano category based on the highest percentage, prior studies suggested that this approach would be oversimplified and would neglect much information in the responses [20,56]. Therefore, Berger et al. [20] presented a user satisfaction level index, including both the Better value and Worse value to measure the extent of the impact that each element would have on a user's satisfaction. More precisely, the Better value indicates the relative increment to satisfaction when a certain element is provided, whereas the Worse value indicates the relative cost to satisfaction when a certain element is absent [57]. The Better and Worse values are calculated as the following Equations (1) and (2) illustrate:

$$\text{Better value} = (O + A)/(M + O + A + I), \quad (1)$$

$$\text{Worse value} = -(M + O)/(M + O + A + I). \quad (2)$$

The Better value ranges from zero to one and the Worse value ranges from -1 to zero. A larger Better value (closer to one) means that the element has greater influences on increasing user satisfaction if present, whereas a smaller Worse value (closer to -1) means that the element has greater influences on decreasing user satisfaction if absent. According to the formulas, we obtained the better–worse value for each gamification design elements in Ant Forest and report the results in Table 7. In addition, not all elements are equally important in the gamification design. In practice, managers have to make decisions under technical and financial constraints, and cannot provide gamification design elements simultaneously. Therefore, we adopted the refined approach in Chen and Kuo [58], incorporating the importance score of each element to generate the weighted better–worse value, which helps managers to make such trade-offs. The weighted better–worse value is calculated by multiplying the original better–worse value with the mean importance score obtained from our questionnaire, as illustrated in the last column in Table 7.

Table 7. Results of better–worse analysis for gamification design elements in Ant Forest.

Gamification Modules	Gamification Elements	Better Value	Worse Value	Importance Mean	Weighted Better Value	Weighted Worse Value
Task Design	task1	0.63	−0.44	4.20	2.66	−1.84
	task2	0.37	−0.31	3.72	1.38	−1.15
	task3	0.61	−0.45	4.26	2.60	−1.91
	task4	0.47	−0.31	3.91	1.83	−1.23
	task5	0.44	−0.24	3.87	1.71	−0.92
Interaction	inter1	0.39	−0.15	3.53	1.37	−0.51
	inter2	0.38	−0.28	3.64	1.38	−1.00
	inter3	0.21	−0.10	3.21	0.68	−0.31
	inter4	0.39	−0.25	3.72	1.45	−0.95
	inter5	0.57	−0.30	4.01	2.27	−1.19
Feedback	fdbk1	0.47	−0.40	3.96	1.88	−1.59
	fdbk2	0.58	−0.36	4.16	2.43	−1.52
	fdbk3	0.42	−0.32	3.91	1.65	−1.27
	fdbk4	0.51	−0.34	3.98	2.01	−1.36
	fdbk5	0.55	−0.30	4.01	2.21	−1.19
Reward	rewd1	0.46	−0.36	3.99	1.82	−1.45
	rewd2	0.53	−0.30	3.91	2.06	−1.17
	rewd3	0.61	−0.25	4.11	2.51	−1.02
	rewd4	0.53	−0.21	3.87	2.03	−0.82
	rewd5	0.67	−0.48	4.24	2.83	−2.02
	rewd6	0.28	−0.17	3.47	0.97	−0.59

To identify the critical gamification design elements in Ant Forest, this study plotted a two-dimensional graph to represent the pairs of weighted Better and weighted Worse values. The horizontal axis is the degree of weighted Better value, and the vertical axis is the degree of weighted Worse value. By comparing to the mean of the weighted Better and weighted Worse value, all elements are divided into four areas in the graph (see Figure 3).

Figure 3. Illustration of weighted better–worse analysis.

Area I indicates elements with both a high weighted Better value and high weighted Worse value (closer to zero), suggesting these elements could increase user satisfaction in Ant Forest but have little influence on decreasing dissatisfaction. These are the Attractive elements developers can keep an eye on. Consistent with our findings in Section 4.1, rewd3 belongs to the category of Attractive elements. That means users will experience a pleasant surprise if the official government acknowledges and certificates their contributions to environmental sustainability [12,50]. Another four Attractive elements are revealed with this refined statistical approach. Similar to the official certificate, the virtual medals awarded by Ant Forest (rewd4), as well as the visualized demonstration of users' green contributions (fdbk5), give a disproportionate increasement in user satisfaction. In addition, the interaction between online friends in Ant Forest is found to be an Attractive element, including helping one another to collect green energy (inter5), or “stealing” green energy from each other (rewd2) [14].

Elements in Area II are low in weighted Better value but high in weighted Worse value, suggesting that they show little influence on both increasing satisfaction and decreasing dissatisfaction. Therefore, these elements are Indifferent ones that might be set the lowest priority in the gamification design [58]. The most surprising finding is that social interaction, an important design module in most games, shows an insignificant impact on user satisfaction in Ant Forest with an exception of inter5. In more

detail, users do not care whether they can communicate, collaborate, or compete with each other in Ant Forest (inter1, inter2, inter3, inter4), because the ultimate purpose of the game is to promote pro-environmental behaviors, which can be fulfilled personally without the help of others. But for inter5, which allows users to help others to collect green energy, is consistent with users' perception of the altruistic value and pro-social nature in Ant Forest, thus increases user satisfaction as an Attractive element. In addition, we also found that the countdown reminder in task design module (task2), and punishment setting in the reward module (rewd6), are both insignificant in Ant Forest. The possible reason might be that users treat Ant Forest as a way to contribute to public welfare rather than an entertaining game, hence paying little attention to whether they can collect green energy quickly or not. Similarly, users in Ant Forest put environmental protection in the first place, thus they will be fulfilled through planting a tree regardless of its species (task5).

Area III involves elements that are rated low in both weighted Better value and weighted Worse value. These elements are essential to users and could be regarded as "Must-Be" elements in Ant Forest, because they lead to extreme user dissatisfaction when absent but have little influence on increasing user satisfaction [40]. As the results indicate, being the owner of the personal carbon account (task4), getting informed of real-time change in the personal carbon account (fdbk1 and fdbk3), and collecting own energy to the personal carbon account (rewd1), are suggested as prerequisites in a game. Interestingly, rewd1 is perceived as a Must-Be element because users put effort into generating their own green energy by engaging in pro-environmental behaviors, whereas rewd2 is only an Attractive element because the green energy stolen from others are supposed to be the fruits of others' labor; thus, it is not a required element at all.

Last but not least, elements in Area IV are high in weighted Better value but low in weighted Worse value, suggesting that these elements have significant influences on both increasing user satisfaction and decreasing dissatisfaction. Therefore, these elements are the most critical One-Dimensional elements, which should become the highest priority of developers in improving the performance of Ant Forest. Consistent with our findings in Section 4.1, the gamification design elements that have a high correlation with environmental sustainability belong to the One-Dimensional elements. Specifically, the background of environmental protection (task1), the design of linking pro-environmental behaviors to green energy (task3), and the reward of a real tree planted in deserts (rewd5), are the competitive advantages of Ant Forest that distinguish it from other games. Meanwhile, the instant display of certificate (fdbk2) and real-time feedback of task completion (fdbk4) illustrate the milestones of users in Ant Forest, which motivate them to engage more in pro-environmental behaviors.

5. Discussions

5.1. Main Findings

To deal with worldwide environmental challenges, it is imperative to find effective approaches to promote environmental sustainability. Ant Forest is an innovative IT-enabled approach to engage people in pro-environmental behaviors through virtual gamification design. Although Ant Forest has reached an early success, the lasting success depends on users' continuous involvement and ultimate behavioral changes.

This study aimed to explore the embedded gamification design to identify key elements that attract users to continuously participate in Ant Forest and eventually foster their pro-environmental behaviors. First, to understand the success of Ant Forest, this study conducted a focus group interview to identify twenty-one gamification design elements in four modules: task design, social interaction, feedback, and reward. Furthermore, this study investigated how these gamification design elements impact users' attitudes towards Ant Forest. Based on the Two-Dimensional Kano Model with a better–worse analysis [19,20], we classified and prioritized the gamification design factors that are important in attaining long-term users in Ant Forest. From a total of 207 valid questionnaires, five

Attractive elements, five One-Dimensional elements, four Must-Be elements, and seven Indifferent elements were identified in Ant Forest.

We obtained several important findings from the Kano Model. First, the gamification design elements that have a high correlation with environmental sustainability (i.e., green context, pro-environmental behaviors, plant a tree) all belong to the One-Dimensional elements, which can facilitate the most user satisfaction and prohibit the most user dissatisfaction. In other words, the “green” elements correspond to the green purpose of Ant Forest, thus constituting the critical elements with the highest priority that distinguish Ant Forest from other games. Second, as a platform for users to contribute to public welfare rather than social entertainment, most elements in the social interaction module show a trivial impact on user satisfaction. Users in Ant Forest can collect green energy through personal pro-environmental behaviors without the help of others, which attenuates the significance of social interactions. Third, most elements in the reward module are found to be Attractive elements that lead to unexpected satisfaction to users in Ant Forest, including both the virtual medals awarded by the game and real certificates provided by the official government. As a game for public welfare, rewards are not a requirement that must be fulfilled, but can provide a surprise to users and motivate them to engage more. Fourth, short-term and long-term feedback have different impacts on user satisfaction. It is necessary for users to get informed of real-time changes in their personal carbon account (when and how many grams of green energy are collected on a given day), which cannot increase user satisfaction because it is a prerequisite of the game. However, the long-term feedback, such as how many trees you have planted and how much green energy you are lacking from planting a tree, are found to be One-Dimensional elements that are positively related to user satisfaction because they represent the milestones of users in Ant Forest. Last, although the embedding of competition elements in the task design module is important in traditional games, it shows no impact in Ant Forest. The countdown setting, the ranking mechanism, as well as the hierarchical tree species are all regarded as insignificant elements.

5.2. Theoretical and Practical Implications

As an interdisciplinary research, this study has profound theoretical implications. First, based on qualitative methods, including the literature review and focus group interview, this study categorizes gamification design elements into four main modules, which provide a theoretical basis for future gamification studies. Second, by focusing on Ant Forest, an innovative gamification application in the environmental protection field, this study identified twenty-one gamification design elements and discovered the mechanism of how best to apply these elements to increase user satisfaction and motivate pro-environmental behaviors. For instance, gamification design elements that are highly correlated with environmental sustainability are found to be critical, whereas elements associated with social interaction and competition show trivial importance in Ant Forest. Third, this study is among the first to adopt the Two-Dimensional Kano Model in the environmental sustainability field, and distinguishes the gamification design elements into Attractive, One-Dimensional, Must-Be, and Indifferent categories.

The findings of this study also yield helpful insights for practice. Different from common games, Ant Forest is a gamified application for a non-game purpose: environmental protection. The practice in traditional gamification design cannot be directly applied to the new context. First, Ant Forest should involve more “green” elements that echo its “green” objective in task design. More pro-environmental behaviors can be introduced to generate green energy, such as Small Office, Home Office (SOHO). Second, it seems that social interaction is not so important in Ant Forest, which turn out to be ineffective in attracting and attaining users. Third, rewards are important in motivating people to participate in Ant Forest. Developers can design a variety of medals and apply for more official certificates from different organizations to acknowledge users’ contributions. Fourth, both short-term and long-term feedback should be provided in Ant Forest, among which the long-term feedback that illustrates the milestones of a user has a higher importance. For instance, a reminder like “your green energy in your

carbon account can plant half of a seabuckthorn tree now” would be a great motivator for users in Ant Forest. Last, as a game aimed at public welfare, the involvement of “competition” elements should be attenuated, which is contradictory to the altruistic and pro-social nature of Ant Forest. In a word, the findings in this research help Ant Forest to refine its gamification design, increase user satisfaction and attract more people to participate in pro-environmental behaviors. Similar applications that are aimed at environmental protection through gamification can also adjust their design based on our findings.

5.3. Limitations and Future Research

There are several limitations in this research. First, the identification of four modules and twenty-one elements was obtained from a focus group interview with several student participants; it will be better if we could invite a few professional gamification designers to present their ideas from another perspective. Second, we only applied the traditional Two-Dimensional Kano Model to classify the gamification design elements; other famous tools such as Importance–Performance Analysis [59] may also be adopted in the future to derive more findings. Furthermore, we used a convenience sampling method thus the sample size is relatively small in this study. Although the sample size is comparable with previous studies that employed the Kano approach, future analysis could enlarge the sample size from populations with diverse backgrounds and conduct more rigorous analyses. Third, although we obtained some findings from a novel approach, the results cannot be empirically verified without a delicately designed experiment. A field experiment should be conducted to examine the impacts of gamification design elements in the future. Last, this research is set in the background of Ant Forest—whether the findings can be applied in other similar applications still needs investigation.

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