

Article

Exploring Sustainability Environment Educational Design and Learning Effect Evaluation through Migration Theory: An Example of Environment Educational Serious Games

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Abstract: Changes in the way people use information come from the concept of the most primitive human migration rule. Scholars hold that migration can be considered as a switching of people's place of residence, but the migration of people is not limited to the migration of residence. The marketing field also borrows the population migration theory to further explore the switching behavior of customers; educationalists also discuss migration of learning through migration theory. In this regard, the migration of human beings is a process of historical evolution, though it takes several decades to understand history from the perspective of such evolution. Hence, if there is a decision-making system that simulates evolution and estimation through 3D graphics, then players may better understand the impact of environmental migration and changes on humanity. This study adopts Push-Pull-Mooring (PPM) theory to explain the migration of human beings. Push is generated from people's dissatisfaction with their place of residence, Pull is from attractions of the new environment, and personal mooring produces the intention of switching. A set of Gamification Environmental Education Applications (GEEA) and a migration scale for such apps are developed herein to explain the state where computer gamers switch to mobile app games. The results show that all four hypotheses are supported, and the path coefficient of each hypothesis is highly significant. The R^2 values of five intrinsic constructs are Push ($R^2 = 0.321$), Mooring ($R^2 = 0.574$), Pull ($R^2 = 0.413$), Switching intention (SI) ($R^2 = 0.552$), and SB ($R^2 = 0.626$), where the R^2 value of SB is quite high, indicating that the relationship between the switching behavior (SB) and the four precursors exhibits great explanatory power. Hence, the explanatory power of this model is convincing, and the teaching materials designed through gamification education deliver better learning outcomes.

Keywords: migration theory; technology acceptance model (TAM) model; theory of planned behavior; simulation games; sustainability environment education

1. Introduction

Environmental education emphasizes knowledge, attitudes, and skills about the environment and education conducted based on a sustainable environment [1–3]. Sustainable environmental education is a vital issue in our time. It is a mutual equilibrium, trade-off, and integration of environmental sustainability, social sustainability, happiness sustainability, and economic sustainability [4,5]. Changes in the way people use information comes from the concept of the most primitive human migration rule. Scholars hold that migration can be considered as a switching of people's place of residence, but the migration of people is not limited to the migration of residence [6]. The marketing field also borrows the population migration theory to further explore the switching behavior (SB) of customers; educationalists also discuss the migration of learning through the migration theory [7]. In this regard, the migration of human beings is a process of historical evolution, while it takes

several decades to understand history from the perspective of such evolution. Hence, if there is a decision-making system that simulates evolution and estimation through 3D graphics, players may better understand the impact of environmental migration and change on humanity. Moon (1995) proposed the Push-Pull-Mooring Theory (PPM) to explain the migration of human beings [8]. Push is generated from people's dissatisfaction with the place of residence, Pull is from attractions of the new environment, and personal mooring promotes migration activities that target for a better and more beautiful life.

The combination of sustainable development education and information education will be the future trend of development and a vital task. With the development of the new model of "computing (ubiquitous computing) anytime and anywhere", new mobility benefits include learning with tablet PCs, as well as more effective teaching and significant learning outcomes. In such framework, it is of great importance to create new value-added tools and teaching procedures. Teaching strategies such as internship, field visit, games, discussion, raising questions, and role play are frequently used in sustainable development education [9]. Game simulation strategies offer multiple advantages such as delightful learning, while reducing stress and anxiety among learners and teachers, improving memory, stimulating student participation, and enhancing overall learning [10]. Gamification learning has become an important topic in economics, society, and research. Many scholars believed that posing challenges remains a vital source of intrinsic motivation in players' environment [11]. In learning materials, gamification plays an important role, not only in driving everyone's intrinsic motivation, but also in learning.

The previous research literature has plenty of areas that use simulation methods to conduct gamification education or solve relevant difficulties, mainly because simulation games have the following features. (1) Realistic effects can be achieved through design of and overall context, and because of this complete context, learners can recall the learning process and content more easily. (2) When designing a simulation environment or a game script, the complex context will be divided and restructured according to the teaching objectives. (3) In the face of uncertain contexts, learners will increase their thinking in the decision-making process. (4) Through instant feedback, learners believe that they have the ability to create a happy, relaxed, novel, and inspiring atmosphere in which they will have courage to do the best [9,12,13]; however, in previous literature, simulation games were seldom used in the field of human social sciences. Therefore, this study fills this gap by extending the theory of migration for developing and designing apps (applications) in gamification environmental education to enhance students' learning outcomes. In this study, a sustainable environmental stimulation city is used to construct a better life indicator of population, economy, electricity, environment and happiness, gradually setting up a stimulation evaluation game featuring sustainable environment education changes. Based on the above motivations, the main purposes of this study are as follows.

- (1) Develop and design gamification environmental education simulation apps.
- (2) Construct a switching intent scale for gamification environmental education simulation apps.
- (3) Verify analysis of complementary learning outcomes of gamification environmental education simulation apps.

2. Literature Review and Research Hypotheses

2.1. Simulation Education Serious Game

The "simulation game" of environmental education simplifies the real situation and copies situational patterns based on the purposes of the game so that players may acquire new knowledge under continuous interaction within this context. "Simulation game teaching" also defines a set of rules to be followed to provide different levels of sophisticated challenges, to guide players in the pursuit of victory, to help them challenge opponents, and to break environmental restrictions in the process of reaching the game goals; the combination of the two is "simulation game law", including both the game design and the simulation scenarios. The famous Beer Game among all simulation

education games was a chain strategy game of simulation supply developed by Sloan School of Management at MIT in the 1960s. In the Beer Game, consumers' demand change was small, but through amplification of the entire system, it would generate a great crisis. Hence, simulation education games arouse competitive/cooperative spirit among players, promote playfulness, achievements and keep challenges, and provide players with rewards through learning and confrontation [14,15]. DeVries and Edwards (1973) pointed out that learning through simulation education games offers easier methods to understand something than through other learning methods [16]. Keller (1987) indicated that games have multiple functions such as teaching, entertainment, and helping to explore new skills, improve self-esteem, practice skills, and change attitudes. When applied in education, it exudes considerable value [17]. Bonk and King (1995) held that playing video games offers real-time brainstorming and inspiration [18]. Based on the above scholars' points of view, games, when applied in learning, can arouse competitive/cooperative spirit among learners, enhance memory, stimulate inspiration, and boost learning willingness [18].

2.2. Migration Theory

Ravenstein proposed "the laws of migration" in 1885 based on the migration situations in the Census of England and Wales and with reference to data from several countries. His view focused on illustrating the phenomenon of migration from rural to urban areas and held that the labor population of migration was mainly limited by both the push and pull effects [19]. A region's push being greater than its pull will lead to migration of residents; conversely, a region's pull being greater than its push will attract more residents (Figure 1). The push-pull theory indicates that the reason for population migration is the push of the origin place of residence, the pull of the migrated place, and the interaction of interferences and obstacles during the process. Migration behavior is caused due to the understanding of migrants towards an objective environment, coupled with the decision-making behavior formed through subjective feelings and judgments. Factors such as fertile land, pleasant climate, better living environment, adequate employment opportunities, better public facilities, education opportunities for children, social stability, and political stability may be incentives to attract more people to migrate. In addition, factors that hinder or interfere with the occurrence of migration or reduce the migration behavior are known as intermediate obstacles, including distance, immigration regulations, and personal factors.

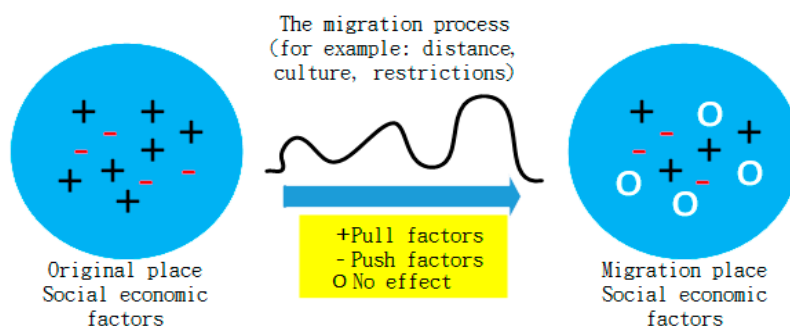


Figure 1. Diagram of factors affecting migration.

2.3. Research Hypotheses

2.3.1. Relation between Push and Intention of Switching

Davis (1989) modified the theory of reasoned action (TRA) and extended the technology acceptance model (TAM) to include two factors: perceptual usefulness refers to the degree to which users subjectively perceive that using a technology can improve work performance; while perceptual easiness refers to the degree of ease-of-use of technology in users' eyes. In his opinion, individual behavior was determined by behavioral intention, and behavioral intention may be affected by Attitude

and Subjection Norm. Users' attitude towards the system may be affected by perceptual easiness and perceptual usefulness, users' behavioral intentions are affected by attitude and perceptual usefulness, and perceptual usefulness is also affected by perceptual easiness [20]. This model has been widely used in a variety of science and technology accepted behavior research, and hypotheses in the model have also been repeatedly verified [21–23]. Multiple previous studies also pointed out that TAM has certain explanatory power for the integration of computer assistance instruction (CAI) and information communicational technology (ICT) in teaching [24–29]. The research results of TAM indicated that users' attitudes towards the usefulness and easiness of technology products have a positive impact on the acceptance attitude and intention of products and proved that perceptual usefulness and easiness have a positive impact on intentions [30–32]. Relevant studies by Fornell (1996) proved that service quality has a positive impact on customer satisfaction, as users may switch behavior when they are dissatisfied [33]. Moon (1995) deemed that once people felt poor quality of life or poor life experience, they would generate a push for migration. Following the correlations among the above literature, this study showed that push is an unsatisfactory effect and mainly composed of four elements: service quality, perceptual usefulness, perceptual easiness, and perceived satisfaction. Hence, this study proposes the following hypothesis.

Hypothesis 1. *The less useful, the more difficult to operate, and the more dissatisfaction towards service quality that gamification environmental education apps exhibit, the stronger the intention of switching will be.*

2.3.2. Relation between Mooring and Intention of Switching

Moon (1995) proposed that in migration theory, mooring refers to the personal and social factors that promote migrants to leave or to stay in their original places of residence. Ajzen (1985) put forward the Theory of Planned Behavior (TPB) [34], which evolved from the TRA. Ajzen (1989) deemed that subjective norms refer to the social pressure felt when an individual takes on a particular act [35]; i.e., the pressure put forth by other important persons or groups that prompt him/her to carry out or not carry out a particular act. The stronger the positive subjective norms are, the easier they stimulate the intention of carrying out such an act. Fishbein & Ajzen (1975) argued that attitude and subjective norms are two of the most important determinants of behavioral intentions. According to the previous literature, TPB can be applied to explain different types of behavior, with all having good explanatory power [36]. Entertainment is often accompanied by elements of fantasy, feeling, fun, and symbolic meaning [37] or festive and ludic feelings [38]. The characteristics of entertainment facets are also commonly used in behavioral studies [38,39] and are thought to be subjective and personal [40]. In terms of system usage, the higher the “entertainment” is felt by users towards the decision-making system, the higher the intention of adoption is [41]. Ajzen (1985) also argued that subjective norms have an impact on consumers' purchasing intentions, while Ajzen (1989) considered that behavioral attitudes and subjective norms directly affect behavioral intentions [35]. Hence, to enhance one's behavior or intention, one must either feel positive about one's behavior or feel more normative pressure around him, and the more control he knows about the behavior, the more positive his behavioral intention is. According to the above literature, the study proposes the following hypothesis.

Hypothesis 2. *The higher the players' subjective norms are and the stronger the attitude of transformation is, the stronger the intention of switching will be.*

2.3.3. Relation between Pull and Switching Intention

Media Richness Theory, also known as Information Richness Theory [42], defines the richness of information as the potential information load of media. In terms of consumption decision, it has been pointed out that whether to obtain rich information is an important factor that influences the

intention of consumer behavior [43]. If consumers are equipped with enough useful information during the consumer decision-making process, then their purchase attitude will be more positive. Rice (1993) argued that different media have different characteristics and different media have different communication effects [44]. Dennis and Kinney (1998) used computers as a medium of communication, as they can immediately provide feedback, transmit multiple clues, and use multi-lingual communication and individual focus [45]. When users perceive the richness of the medium of an information system, their perceptual entertainment will be positively affected [46]. Dialogues between information systems and users, in addition to interaction between both sides, can respond to information and content provided by information systems [47]. Interactivity has a positive impact on the practicality of information systems and helps create better consistency between attitudes and usage behavior [48]. Ennew, Banerjee, & Li (2000) pointed out that a company's reputation has a greater impact on consumer behavior than advertising and personal marketing and even plays an important role in the diffusion of new products. Hence, reputation also has a direct impact on consumers' willingness to switch or buy. Lee (1966) even found that migration pull would be produced if there was better quality of life in the process of migration [49]. As a result, service providers and consumers with higher subjective norms, higher information richness, and good reputation feel stronger intention about switching. From the above literature, the effects of pull as a substitute include information richness, reputation and trust, perceptual risk, switching intention (SI), and SB. Therefore, this study proposes the following hypothesis.

Hypothesis 3. *The richer the information is and the lower the risks are regarding, the stronger the SI of the player will be.*

2.3.4. Relation between SI and SB

The TPB proposed by Ajzen and Fishbein (1980) consists of three factors: behavioral attitudes, subjective norms, and perceived behavioral control. Thus, to enhance one's behavior or intentions [50], one must either feel positive about one's behavior or perceive more normative pressure around oneself. The more the perceived control is, the more positive the behavioral intention is. Ajzen (1989) showed that intentions have a direct positive correlation with behavior. Davis (1986) also pointed out in a TAM study that attitude, intention, and behavior have a positive relationship. TAM also illustrates the direct impacts of perceptual usefulness and perceptual easiness on intentions and the employed impacts on attitudes and behavioral intentions for generating actual system behavior. Behavioral intention is a tendency and refers to positive or negative views or feelings that users have towards on a new technology. Many previous studies [35,51] obtained empirical results showing that behavioral intentions play an important role in the actual use of behavior. Therefore, according to the above literature, the study proposes the following hypothesis.

Hypothesis 4. *The SI of gamification environmental education Apps has a significant positive impact on SB.*

3. Research Method

3.1. Design and Indices of Environmental Education Teaching Materials

Environmental education is a process of conceptual cognition and value clarification to develop the skills and attitudes necessary to understand and appreciate the interrelationships among human beings, cultures, and other biological and physical environments. Environmental education arouses students' awareness and sensitivity to the environment through various teaching activities. It can enrich students' knowledge of sustainable environment, enabling them to cultivate correct values on the interaction between people and environment and to address regional or global environmental issues. Based on the learning indices of environmental education (e.g., Table 1), this study designs an

interactive 3D action environmental education simulation teaching material. Through the design of gamification digital media teaching materials, students can achieve the understanding and skills to improve or solve environmental problems, to establish learners' experience of environmental actions, and cultivate them into citizens of environmental literacy. The following five aspects are listed to specifically describe environmental education curriculum objectives: (1) environmental awareness and environmental sensitivity; (2) environmental concept knowledge; (3) environmental ethical values; (4) environmental action skills; and (5) environmental action experience.

Table 1. Environmental education curriculum learning indices.

Connotation	Learning Objectives	Game Level Design Description	Competency Indices
(1) Environmental awareness and understanding of the environment	Cultivate students' awareness of all kinds of environmental damage and pollution, as well as their appreciation and sensitivity to the natural environment and fabricated environment.	Experience environmental issues (such as floods, landslides, limited resources, nuclear pollution, and energy).	1-1 Use sensory observation to explore things in the environment. 1-2 Inspire and appreciate the beauty of nature through physical sensory with animals, plants, and landscapes in the natural environment.
(2) Environmental concept knowledge	Teach students to understand the basic concepts of ecology, environmental issues, resource conservation and reuse, simple life, and ecological design.	Understand the connotation of living and international environmental issues and explore in-depth their impact on human society and development.	2-1 Understand the natural environment around the life and basic ecological principles.
(3) Environmental values and attitudes	Promote the teaching of environmental ethics and cultivate students' positive environmental attitude towards the survival and development of future generations.	Understand the interaction and interdependence relationship between people and the environment and respect the living value of all kinds of creatures in the environment.	3-1 Love creatures through contact and avoid harming the biological growth of environmental conditions. 3-2 Have curiosity and think about the meaning and value of all things in the environment.
(4) Environmental action skills	Teach students to identify environmental issues, study environmental issues, assess possible solutions, analyze environmental actions, and take environmental action.	Use scientific methods to study feasible strategies for solving environmental problems and make good use of problem-solving strategies to solve environmental problems.	4-1 Apply information and record collection methods to understand and recognize the environmental problems on campus and in residences and to propose concrete solutions to problems in the living environment.
(5) Environmental action experience	Integrate environmental action experiences into learning activities and develop students' abilities to address problems in the living environment to give them a sense of belonging and participation in the community.	Propose solutions to problems of the living environment and draw up a plan of action on community environmental protection.	5-1 Experience participating in community environmental protection or caring for vulnerable ethnic groups with parents or teachers. 5-2 Plan and implement individual and collective campus environmental activities.

3.2. Use Context and Interface Design

This study applies PPM theory to implement and evaluate the gamification environmental education apps system. The design adopts a simulation game (simulation) as a reference. Through computer simulation of the real-world environment and events, players are provided with a game similar to real-life situations. The game uses everyday life as a backdrop, allowing players to manipulate simulated characters in everyday life, community exchange, and building houses. In such a simulated world, the real-life situations are simulated, and physical and mental needs are controlled, and they are coupled with multiple creative ideas to increase the attractiveness of the game and the style of its design, as shown in Figures 2–5.



Figure 2. Interface of environmental education policy.

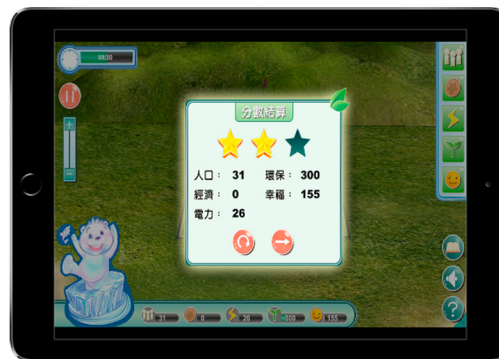


Figure 3. Achievement environmental education policy.



Figure 4. Interface of problem-solving strategy game.

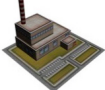


Figure 5. Environmental education policy game assistant tool.

The contents of this game are mainly for the construction of buildings to maintain the balance between urban development and construction and environment. Each building, as illustrated in Table 2, enables learners to understand the environmental impact of each construction and the principle of

renewable energy. The main content of the teaching activities centers on destruction to the environment that arises from over-exploitation as well as the importance of advocating environmental protection. Learners will play the role of builders in the game. In the process of construction and development, the environment will drop in value. In this regard, green buildings must be constructed to improve the environment. The construction of green buildings will also cause economic decline, and learners need to maintain a balance between the two. In terms of the main playing of the game, construction may be divided into five categories: population, economy, electricity, environment, and happiness (Table 2). In the process of construction of the population, economy, and electricity, the quality of environment will be affected, representing destruction of the environment. Hence, efforts should be made to build environmental buildings or build buildings with renewable energy to improve the environment. However, environment-based construction will affect economic development. Players must find ways to strike a balance between economy and environment to learn the impact of technological development and environment.

Table 2. Index description of gamification environmental education performance.

Name	Category	Extra Point Effect	Instruction
	Population (Apartment)	Population +10 Economy −5 Electricity −3 Environment −4	Apartment is a kind of aggregative house and refers to a pattern of complete living facilities.
	Business (Refinery)	Economy +5 Electricity −3 Environment −3 Happiness −3	Refinery is a factory that processes refined petroleum products and separates the refined crude oil into multiple useful petroleum products.
	Business (Industrial area)	Population −3 Economy +12 Electricity −8 Environment −5 Happiness −5	Industrial area refers to an area with abundant industrial facilities (especially shipbuilding, mining, steel, ceramics, and other heavy industries).
	Electricity (Wind power plant)	Economy −2 Electricity +3. Happiness +3	Power plants that use wind to generate electricity are one type of renewable energy power plants.
	Electricity (Thermal power plant)	Economy −4 Electricity +2 Environment −3 happiness −5	Thermal power plants are power plants that generate electricity by burning coal, natural gas, or oil.
	Electricity (Nuclear power generation)	Population −3 Economy −15 Electricity +15 Environment −12 Happiness −10	Nuclear power uses controlled nuclear reactions to obtain energy for power, heat, and electricity.
	Environment (Metropolitan park)	Population +1 Economy −1 Environment +5 Happiness +5	Provides recreational places for the public. The parks can refer to the following places.
	Happiness (Police and fire center)	Economy −5 Electricity −3 Environment −2 Happiness +3	Police station means the police agency at the local government level. Fire station includes firefighting facilities with buildings for firefighters.
	Happiness (Hospital)	Economy −7 Electricity −6 Environment −4 Happiness +10	Hospitals are institutions that provide medical and recuperation services to people who suffer serious psychological or physiological illnesses.

3.3. Environmental Simulation Real-Time Strategy Game Process

The operation procedure of the environmental education simulation real-time strategy game is shown in Figures 6 and 7. Since this game is based on real-time decision-making under the development of sustainable environmental education based on the five dimensions of population, economy, electricity, environment, and happiness, any event will happen immediately and players

must decide to handle which incident immediately to response and solve the problem. For example, in terms of environmental problems, if there is a lack of power infrastructure in urban development, then there are five sources of electricity (nuclear, wind, waterpower, thermal, and solar power) available to players. However, the source of nuclear energy selected by players will lead to a negative impact on the environment and gradually reduce the environmental health index. Players need to instantly determine whether to develop an economy or create a happy city. If players choose wind power, though this can avoid a decline in the environmental health index, the cost at the same time will result in a decrease in the economic index. If the economic indicators continue to decline to a certain level, then this will lead to social happiness and public order problems and even to social theft events. The social stability index will at the same time also gradually decline. At this moment, players should immediately send the police to maintain social order, thus raising the social stability index. Players need to invest in green alternative energy after achieving an economic balance. Though the economy index will decline, and the social stability index will also drop due to investment in alternative energy sources, the environmental index will go up. The five indices of population, economy, electricity, environment, and happiness will also change. After the game is over, for a limited time, the system will calculate the balance value of players in population, economy, electricity, environment, and happiness, as their results. Figures 2–5 illustrate the operation chart of a sustainable environmental education strategy game.

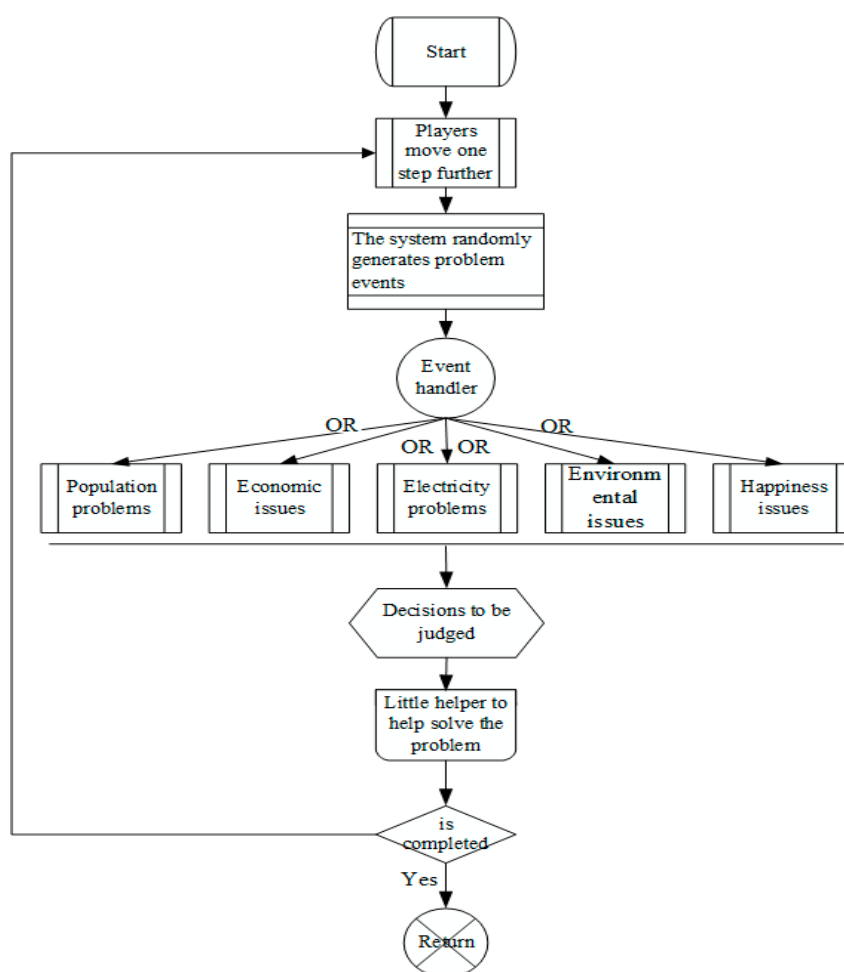


Figure 6. Parallel event strategy simulation flowchart.

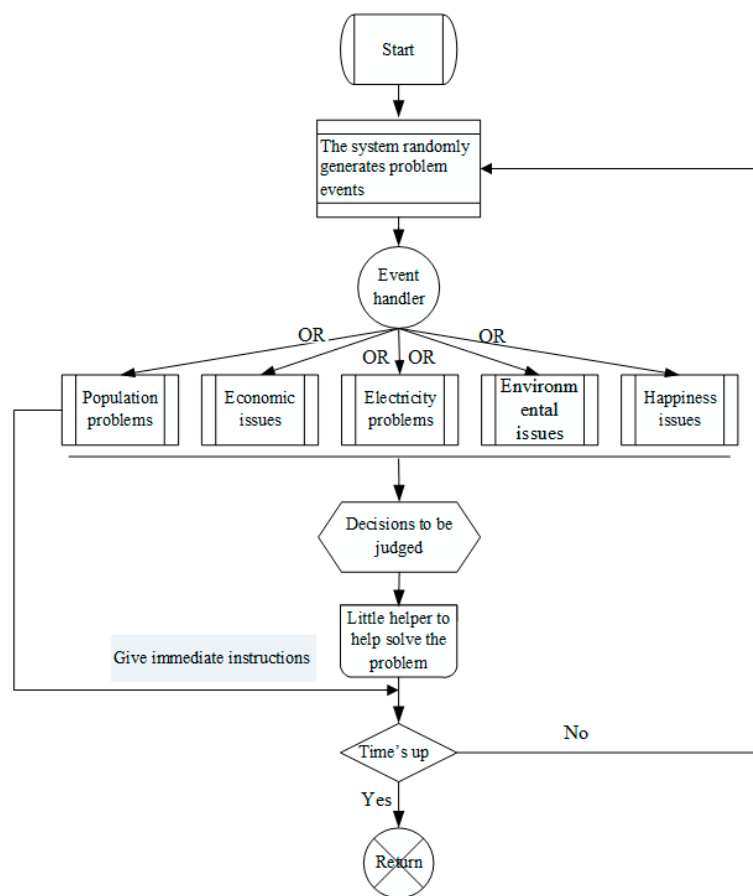


Figure 7. Real-time strategy simulation flowchart.

3.4. Research Structure

Based on the PPM, TAM, and TPM, and the Media Richness Theory proposed by Moon (1995), this study proposes the integration of PPM theory in gamification environmental education design and learning outcome evaluation. Figure 8 shows the research model and operational definition (Table 3), including the dissatisfaction effect of the second-order facets of Push—that is, service quality, perceptual usefulness, perceptual easiness, and perceived satisfaction; Mooring facet contains subjective norms and attitudes of transformation; while the effect facets of the alternatives of Pull include information richness, reputation, trust and perceptual risk, SI, and SB.

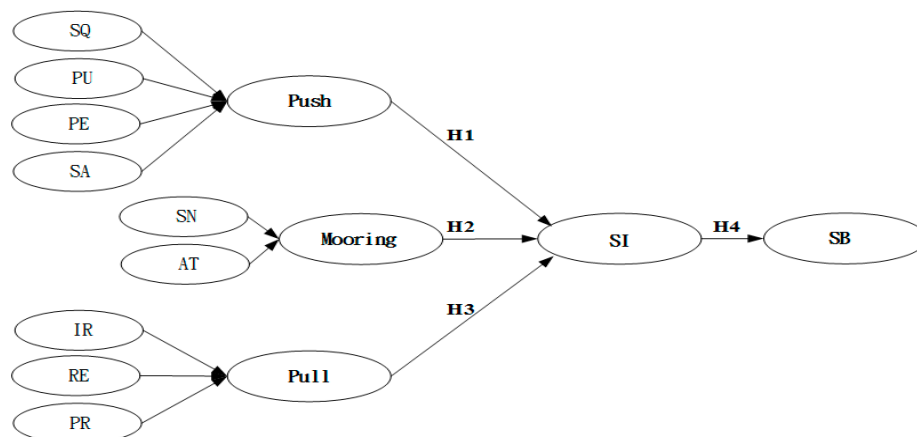


Figure 8. Gamification environmental education Apps' switching model architecture.

Table 3. Operational definition of the constructs and questions of the questionnaire.

Construct	Potential Variables	Operational Definition	Question	Reference Source
Push	Perceptual usefulness (PU)	Users believe that using a system can increase the subjective perception of their effectiveness.	PE1 I think the functions are easy to operate.	[52]
			PE2 I find it easy to use.	
			PE3 It is easy after reading the instructions.	
	Perceptual easiness (PE)	Users recognize that technology is easy to use and are more confident about self-efficacy and self-control.	PU1 It can let me get a great deal of useful information.	
			PU2 It will improve my learning outcome.	
			PU3 It is helpful to me.	
	Service quality (SQ)	Understand how customers feel and evaluate customer service.	SQ1 I pay attention to the easiness of operation and use.	[53,54]
			SQ2 I focus on the reaction time and speed during implementation.	
			SQ3 I focus on operational reliability.	
			SQ4 I focus on the stability of operation.	
	Perceptual satisfaction (SA)	The higher the customer satisfaction is, the less switching behavior there will be.	SA1 The service provided makes you feel happy.	[55]
			SA2 The service is provided with a good attitude.	
			SA3 The service provided makes you satisfied.	
			SA4 The service provided is for full implementation of problems.	
Mooring	Subjective norms (SN)	A measure of a person's behavior—that is, the expectations of family members or social pressure.	SN1 My family thinks that using an environmental education game can be fun online.	[51,56]
			SN2 I do not like to let people know I use environmental education games.	
			SN3 My friend thinks that using environmental education games can be fun online.	
	Attitude of transformation (AT)	External behavior attitude presented during transformation.	AT1 I showed a good attitude during transformation.	
			AT2 I showed a satisfying attitude during transformation.	
			AT3 I was happy during transformation.	
			AT4 I was wise during transformation.	

Table 3. Cont.

Construct	Potential Variables	Operational Definition	Question	Reference Source
Pull	Information richness (IR)	Information is a factor affecting customer spending behavior.	IR1 Overall, environmental education games are more diverse than my current information.	[7,56]
			IR2 Overall, environmental education games feature richer information than my current information.	
			IR3 Overall, environmental education games are funnier than my current information.	
	Reputation and trust (RE)	Impact of reputation on consumer behavior is greater than advertising.	RE1 I feel satisfied towards the functions of the environmental education game.	[7]
			RE2 I feel content with the functions and services of the environmental education game.	
			RE3 I agree with the functions and services of the environmental education game.	
			RE4 I have recommended friends to use the environmental education game.	
	Perceptual risk (PR)	Personal sales, even in the spread of new products, occupy an important position.	PR1 I am worried about spending much time collecting information.	
			PR2 I am worried about spending much time learning how to use it.	
			PR3 I feel anxious about the use of environmental education games.	
			PR4 I regret using the environmental education game.	
Switching intention (SI)		The use of the system is determined by the behavioral intentions and is affected by the personal attitudes and perceptual usefulness of technology.	SI1 In the next 3 months, I will want to abandon the current system and go play new environmental education games.	[7]
			SI2 In the next 3 months, I may abandon the current system and go play new environmental education games.	
			SI3 In the next 3 months, I will certainly abandon the current system and go play new environmental education games.	
Switching behavior (SB)		Actual behavior during the switching process.	SB1 For me, it would be a good idea to switch to a new environmental education game.	
			SB2 For me, it would be useful to switch existing teaching materials with environmental education games.	
			SB3 For me, it would be helpful to switch existing teaching materials with environmental education games.	
			SB4 For me, it would be clever to switch existing teaching materials with environmental education games.	

3.5. Operational Definition of Constructs

For the development of scale, the complete questionnaire is divided into 11 sections and 39 questions (Table 3). In the Push section, the service quality was modified from the findings of Ho & Lee (2007), and perceptual usefulness (PU) and perceptual easiness were modified from the research items of perceptual satisfaction [52]. In the Mooring section, subjective norms and switching attitudes were modified from the research items of Taylor & Todd (1995). In the Pull section, information richness is measured by questions from Chen & Tan (2004), while reputation and trust are modified from Bansal et al. (2005), and perceptual risk uses the questions items of Kim et al. (2008). The question items about SI and behavior also come from Bansal et al. (2005). In terms of the complete questionnaire, except for the basic information of the respondents, the rest of the scale is a Likert seven-point scale.

3.6. Subjects and Testing of the Samples

The research subjects are divided into two stages: the first stage is the using intention model verification, and the second stage is the learning outcome verification of gamification environmental education. Users who have used the gamified environmental education apps before will be the main survey subjects, and the questionnaire and data analysis will be employed to verify the hypotheses and path relationship of this study. For verification of using the intention model, the study employs questionnaires on the Internet. The questionnaire contains 2 parts: the first part is basic information, and the second part is the using scale of gamification environmental education apps; we collected a total of 156 valid questionnaires. The results showed that all variables are not significantly different between respondents in stage 1 and stage 2, indicating that the non-response bias in this study is not severe. The common method variance (CMV) test uses an unrotated factor to analyze the variables of a single factor, and if one accounts for more than 50% of variability, then there is severe common method variance. The research results showed that factor analysis extracts a total of eight factors with eigenvalues greater than 1. The first factor's explanatory variance is 28.33% (maximum), which is less than 50%, and the cumulative variance of the eight factors is 85.26%. Therefore, there is no obvious common source bias in this study.

3.7. Learning Outcome Experimental Design

The second stage is the learning outcome verification of the gamification environmental education. To understand the outcome of environmental education in the experimental group and control group, in addition to the mean, standard deviation, and post-test covariance analyses of pre-test and post-test unit test of environmental education in the two groups, average and standard deviation statistical analyses are also conducted for the environmental education App learning system satisfaction questionnaire of the experimental group. The experimental group used the gamification environmental education App learning system, and the control group adopted the general learning course for 10 weeks' teaching experiment. A total of 78 students in the experimental group (boys = 40, girls = 38) received a gamification environmental education App learning system. The quasi-experimental design steps are shown in Table 4.

Table 4. Quasi-experiment design.

Groups	Before the Experiment	Experimental Variables	After the Experiment
Experimental group (N = 78)	O1	X1	O3, O5
Control group (N = 78)	O2		O4

Note: O1–O2: Environmental education learning outcome test; O3–O4: Post-test of environmental education learning outcome; O5: Gamification environmental education APP learning system satisfaction questionnaire; X1: Environmental education learning + gamification environmental education APP learning system (control group: environmental education learning + teaching and explanation of teachers in classroom).

1. Independent variables: Before the experiment, the experimental group and control group: (1) adopted traditional classroom teaching and learning; (2) used environmental education

- textbooks and handouts teaching for self-study; and (3) took an environmental education learning outcome test.
2. Control variables: (1) For the same auxiliary learning resources, in the elective courses the two groups of students were already familiar with the environmental textbooks and handouts and interacted with teachers, teaching assistants, and students in the classroom; and (2) each of the two groups had one assistant to assist with problem-solving and consultation; (3) for the environmental education study, the experimental group adopted the gamification environmental education apps learning system to conduct interactive demonstration teaching and learning, while the control group was led by teachers to carry out textbooks, handouts, and teaching materials learning; and (4) for the same learning outcome assessment tool, the groups used the same environmental education learning outcome before and after the test.
 3. Dependent variables: The college students of the experimental group and control group took an environmental education learning outcome post-test, and the college students of the experimental group filled in the “gamification environmental education apps learning system satisfaction questionnaire”.

3.8. Quasi-Experimental Design and Research Tools

(1) Environmental education learning outcome test

In this study, the “environmental education learning outcome test” is a set of questions prepared independently with a total grade of 100 points. The quiz exam consists of the following five modules:

- (a) Environmental awareness and understanding of the environment—10 questions;
- (b) Environmental concept knowledge—10 questions;
- (c) Environmental values and attitudes—10 questions;
- (d) Environmental action skills—10 questions;
- (e) Environmental action experience—10 questions; for a total of 50 questions.

(2) Satisfaction questionnaire on system application

The satisfaction questionnaire of the gamification environmental education apps learning system was prepared independently based on the teaching objectives, learning materials, objectives of environmental learning activities, and characteristics of the learning system during activities. The questionnaire includes 5 parts:

- (a) Use interface design—5 questions;
- (b) Use stability—5 questions;
- (c) Human-computer interaction—5 questions;
- (d) System teaching potential—5 questions;
- (e) System entertainment—10 questions; for a total of 30 questions.

Two questionnaires used expert validity in terms of validity, including: 3 game learning design experts, 3 environmental education experts, 1 mobile App design expert; and revisions were made according to their suggestions. After factor analysis and project analysis of the pre-test questionnaire, the “Environmental Education Learning Outcome Test” was reduced from 55 questions to 50 questions. The reliability coefficient Cronbach’s α of the total scale was 0.912; questions in the “gamification environmental education App learning system satisfaction questionnaire” were reduced from 35 to 30, and the reliability coefficient Cronbach’s α value of the scale was 0.935. Cronbach’s α is a tool for assessing the reliability of scales [57].

4. Empirical Analysis and Results

The analysis and estimation steps of PLS-SEM in this study are carried out using four-stage analysis steps. The first stage is the reliability and validity analysis of the measurement model.

The second stage is the analysis of the path coefficient of the structural model and the ability of model prediction. The third stage is to check the good of fitness and indices of structural models. The fourth stage adopts a quasi-experimental design for the learning outcome analysis and the detailed step descriptions, such as detailed descriptions in each subsection [58–64].

4.1. Sample Descriptive Statistics

Of 156 valid questionnaires in this study, 86 were males (55.1%) and 70 (44.9%) were females. In terms of age distribution, users under 24 years old accounted for 43.8% of the valid samples, users aged 25–34 accounted for 27.2%, users aged 35–45 accounted for 16.8%, and users aged 46–55 accounted for 12.2%. Hence, it can be found that users of the gamification environmental education apps are dominated by younger age groups. In terms of educational attainment, universities and colleges accounted for 53.6% of the total, followed by high school students accounting for 40.5% of the valid samples. In terms of users' occupations, a large majority of users were students, accounting for 58.1% of the valid samples. For weekly frequency of use, 2–3 times a week is the most frequent, accounting for 56.8% of the valid samples. For each use of time, less than 30 points take the most, accounting for 54.8% of the valid samples.

4.2. Measurement Model Analysis

According to the three principles of convergent validity proposed by Fornell & Larcker (1981), the testing of convergent validity of the proposed constructs should satisfy three conditions: (1) Factor loading (λ) should be significant and above 0.5 [58]; (2) The value of component reliability (CR) should be greater than 0.6; (3) Discriminant validity—The average variation extract (AVE) value should be greater than 0.5 [58] and cross-loading [58]. The reliability analysis of all aspects of the study is shown in Table 5, in which the level of factor loading is all significant at $p = 0.001$, all items are higher than 0.5, and the CR is between 0.82 and 0.95—both of which are greater than 0.8. The AVE ranges from 0.71 to 0.86, all of which exceeds 0.5. Hence, the study meets the above three conditions. The factor loading of all items in the model is between 0.71 and 0.93 and reaches a significant level of p -value 0.05, and so it has convergent validity [58]. The estimation of discriminant validity was mainly tested in two aspects [65]. One examines the cross-loadings. For each of the variables in this study, the load of individual questions is higher than that of other variables [66]. The other one employs the Fornell-Larcker criterion—that is, the AVE value of each variable must be greater than the square of the correlation coefficient between pairs of variables to show the discriminant validity of each research variable [66,67]. Table 6 shows that the square roots of the average variation extractions of all variables are larger than the conditional value among variables. Table 5 shows that the load of an individual question in the variables is higher than that of other variables. Therefore, the study's variables have acceptable reliability and validity.

Table 5. Analysis of factor loadings of variables.

Constructs	Potential Variables	Questions	Factor Loading	T-Value	VIF	CR	AVE	Cronbach's Alpha
Push	Perceptual easiness (PE)	PE1	0.93	12.721	1.63	0.95	0.86	0.93
		PE2	0.90	10.087				
		PE3	0.86	11.341				
	Perceptual usefulness (PU)	PU1	0.87	21.232	2.21			
		PU2	0.72	30.211				
		PU3	0.76	25.786				
	Service quality (SQ)	SQ1	0.86	24.875	2.11			
		SQ2	0.85	21.875				
		SQ3	0.83	17.328				
		SQ4	0.76	29.231				
	Perceptual satisfaction (SA)	SA1	0.90	27.982	1.85			
		SA2	0.72	25.189				
		SA3	0.71	29.234				
		SA4	0.82	18.123				

Table 5. Cont.

Constructs	Potential Variables	Questions	Factor Loading	T-Value	VIF	CR	AVE	Cronbach's Alpha
Mooring	Subjective norms (SN)	SN1	0.90	29.234	1.92	0.92	0.76	0.94
		SN2	0.90	21.832				
		SN3	0.86	28.345				
	Attitude of switching (AT)	AT1	0.87	16.234	1.41			
		AT2	0.72	40.123				
		AT3	0.76	30.231				
		AT4	0.86	31.982				
Pull	Information richness (IR)	IR1	0.85	25.712	1.61	0.82	0.71	0.81
		IR2	0.83	24.234				
		IR3	0.76	21.198				
	Reputation and trust (RE)	RE1	0.90	17.291	1.71			
		RE2	0.90	29.297				
		RE3	0.86	27.826				
		RE4	0.87	25.197				
	Perceptual risk (PR)	PR1	0.72	29.230	1.15			
		PR2	0.76	12.723				
		PR3	0.86	10.219				
PR4		0.85	11.981					
Switching intention (SI)		SI1	0.83	21.123	1.81	0.82	0.78	0.78
		SI2	0.76	30.871				
		SI3	0.87	25.854				
Conversion behavior (SB)		SB1	0.72	24.810	1.90	0.85	0.77	0.79
		SB2	0.71	21.812				
		SB3	0.82	17.312				
		SB4	0.76	29.980				

Table 6. Reliability and validity analysis.

	Mean	STD	Push	Mooring	Pull	SI	SB
Push	5.21	1.2	0.93				
Mooring	4.83	1.5	0.6	0.87			
Pull	4.61	1.3	0.62	0.53	0.84		
SI	4.93	1.1	0.55	0.45	0.66	0.88	
SB	4.74	1.3	0.49	0.46	0.65	0.58	0.88

The bold value is higher than the diagonal value of the row and column in the latent construct correlation coefficient matrix.

4.3. Structural Model Analysis

Step 1—Evaluate problems of structural pattern multicollinearity (VIF). Step 2—Criteria for significance of path coefficients. Step 3— R^2 value and path factor tests [58–64]. First, variance inflation factor (VIF) was used to evaluate multicollinearity to understand whether there is any problem of multicollinearity. The results showed that the maximum VIF is 2.21 (Table 5), which is between the recommended value of $0.2 < VIF < 5$ [68], indicating that there is no problem of multicollinearity. The analysis results of the structural model variable effect are shown in Figure 7. This study conducts complete model analysis. The path coefficient of Push and SI is 0.231 ($t = 1.78$), showing a significant level, and so H1 holds true. The poorer the usefulness of the gamification environmental education apps is, the harder they are to operate; the more dissatisfactory the service quality of the game is, the stronger the intention of switching environmental education simulation games is. The path coefficient of Mooring and SI is 0.262 ($t = 2.93$), showing a high level of significance, and so H2 is supported. The higher the players' subjective norms are, the stronger the switching attitude is and the stronger the switching intention is. The path coefficient between Pull and SI is 0.283 ($t = 2.124$), showing a significant level, and so H3 holds true. If players get more information, and the reputation and trust and PR are lower, then players' intention to switch gamification environmental education apps is stronger. The path coefficient of switching intention (SI) and switching behavior (SB) is 0.365 ($t = 2.82$), showing a significant level, and so H4 is established. The higher the switching intention of the gamification environmental education apps is, the stronger the switching behavior is. Generally speaking, PLS refers to the R^2 value in the intrinsic construct of the evaluation model for overall valuation model fitness [61]. From Figure 9, the R^2 values of the five endogenous constructs are: Push ($R^2 = 0.321$), Mooring ($R^2 = 0.574$), Pull ($R^2 = 0.413$), SI ($R^2 = 0.552$), and SB ($R^2 = 0.626$);

where the R^2 value of SB is quite high, representing the relation of the explanatory power between SB and the four antecedent factors is good and the unexplained residuals are small, indicating that the SB and its antecedent factors fit quite well. Therefore, the explanatory power of these five endogenous conceptions is good, denoting that the explanatory power of the research model is quite good, which is in line with the proposed criteria of Cohen (1988).

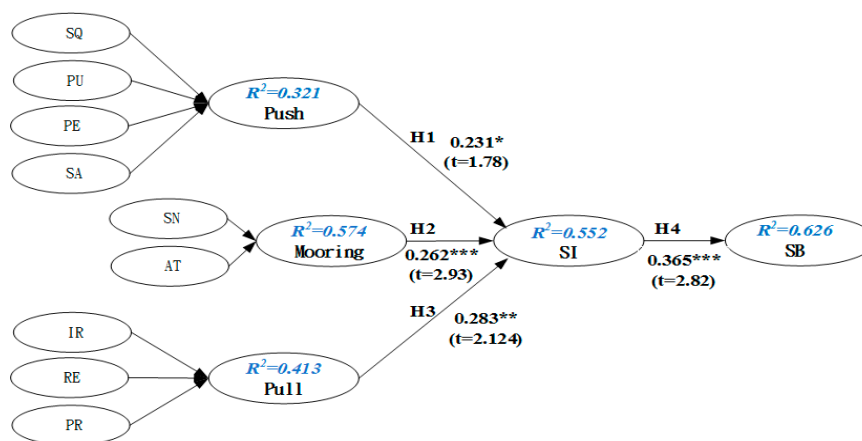


Figure 9. Gamification environmental education Apps' usage intention path factor results.

4.4. Goodness of Fit and Indices of Structural Model

The path coefficient measures the direct impact of potential independent variables on potential dependent variables, and the potential independent variables may have an indirect effect on potential dependent variables via other variables. Among them, the direct influence is also called the direct effect, and the indirect influence is also called the indirect effect, both of which can be calculated through path coefficients. The sum of direct and indirect effects is called Total Effects, as shown in Table 7. The explanatory power of the potential variables of Push, Mooring, and Pull is 55.2% for SI, and the explanatory power of the SI potential variables is 62.6% for SB, indicating that the model has a high degree of potential variability and that the model has predictive capacity.

Table 7. Analysis results of the structural model variable effect.

	Push	Mooring	Pull	SI		SB		
				Direct	Indirect	Direct	Indirect	Total Teaching Effect
Push	–	–	–	0.231	–	–	0.084	0.084
Mooring	–	–	–	0.262	–	–	0.096	0.096
Pull	–	–	–	0.283	–	–	0.103	0.103
SI	–	–	–	–	–	0.365	–	0.365
R^2	0.321	0.574	0.413	0.552		0.626		
f^2	–	–	–	0.18		0.25		
Q^2	0.13	0.15	0.17	0.25		0.48		
GoF	0.51							

The index and fitness of the structural model are based on the five steps proposed by the relevant scholars. Step 1—Criteria for the significance of path coefficients. Step 2— R^2 value and path coefficient verification. Step 3—effect value f^2 evaluation. Step 4—prediction of relevance (Q^2) evaluation. Step 5—goodness-of-fit (GoF) model fitness index [29,65,68–70]. In addition to evaluating the model predictive power, the effect value f^2 of structural models is also an important measure of performance. In addition to the evaluation of all intrinsic constructs of the f^2 value, the evaluation method of effect value R^2 is to delete a particular external derivative in the model to arise a change in the R^2 value, which can be used to evaluate whether the person being removed has a significant effect on the internal variables. The general rule of evaluating f^2 is that the three values of 0.02, 0.15, and 0.35 respectively represent small, medium, and large effects of the external potential variables [71].

Table 7 shows the effect size of f^2 , with the average being greater than 0.15, indicating a medium effect. In terms of the prediction of the relevance of Q^2 to evaluate the prediction's accuracy, in addition to the R^2 value, researchers should also check the Q^2 value from Stone-Geisser [72,73], which is an indicator of predictive relevance. As shown in Table 7 of the structural pattern, the Q^2 value of the intrinsic latent construct is greater than 0, which means that the patterns of the path and the construct have predictive correlations. Tenenhaus et al. [70,74] put forward an overall GoF of PLS as a “program to verify PLS overall model”. Wetzels, Odekerken-Schröder, & Van Oppen (2009) proposed to adopt a communality 0.50 value [66,75] and R^2 value [71] as the evaluation for GoF_{small} (0.10), GoF_{medium} (0.25), and GoF_{large} (0.36) of the PLS structural model goodness. As shown in Table 7, the GoF of 0.51 for this study is greater than 0.36, indicating that the structural model fits well.

4.5. System Learning Outcome Analysis

From the analysis (Table 8) of the pre-test experimental group and pre-test control group, we find that there is no significant difference ($t = 0.018$, $p > 0.05$) between the two groups of college students in terms of prior knowledge in the t test of environmental education learning. The post-tests of environmental education game learning of students from the experimental group and control group are summarized (Table 9), and the results are shown in five course units: (1) environmental awareness ($t = -0.247$, $p < 0.01$); (2) environmental conceptual knowledge ($t = 0.562$, $p < 0.01$); (3) environmental value and attitudes ($t = -6.766$, $p < 0.001$); (4) environmental action skills ($t = -6.573$, $p < 0.001$); and (5) environmental action experience ($t = -0.251$, $p < 0.01$); and a significant difference is achieved in terms of overall learning outcome ($t = -9.121$, $p < 0.001$), indicating that the environmental education learning outcome of students from experimental groups is better than that from the control group. It is conducive to improving students' environmental education learning outcome. According to results of covariance analysis of the experimental group and control group in this study, we see from Table 10 that the experimental group's performances of (1) environmental awareness unit ($f = 20.197$, $p < 0.001$), (2) environmental conceptual knowledge ($f = 28.170$, $p < 0.001$), (3) environmental values and attitudes ($f = 17.124$, $p < 0.001$), (4) environmental action skills ($f = 28.125$, $p < 0.001$), (5) environmental action experience ($f = 27.230$, $p < 0.001$), or overall learning outcome ($f = 34.024$, $p < 0.001$) are all better than the control group, indicating that using the gamification environmental education apps for simulation environmental education learning is conducive to improving students' environmental education learning outcome.

Table 8. T Test of the pre-test for the learning outcome of environmental education in the control group and experimental group.

Unit	Control Group Pre-test (n = 78)		Experimental Group Pre-test (n = 78)		T Test	p-Value
	M	SD	M	SD		
(1) Environmental awareness	78	11.35	77	10.31	−0.171	0.866
(2) Environmental conceptual knowledge	80	10.21	81	9.45	−0.171	0.866
(3) Environmental values and attitudes	79	9.12	78	11.23	0.065	0.950
(4) Environmental action skills	83	11.54	81	9.61	0.069	0.986
(5) Environmental action experience	77	8.32	78	9.46	0.071	0.990
The total scale	79.4	10.108	79	10.012	0.018	0.885

Note: Experimental group n = 78, control group n = 78; $p > 0.05$.

Table 9. T Test of the post-test for the learning outcome of environmental education in the control group and experimental group.

Unit	Control Group Post-test (n = 78)		Experimental Group Post-test (n = 78)		T Test	p-Value
	M	SD	M	SD		
(1) Environmental awareness	77	11.72	85	7.51	−0.247 **	0.001
(2) Environmental conceptual knowledge	81	10.63	85	8.11	−0.562 **	0.002
(3) Environmental values and attitudes	82	10.25	87	7.53	−6.766 ***	0.000
(4) Environmental action skills	81	10.81	84	7.12	−6.573 ***	0.000
(5) Environmental action experience	78	9.77	85	6.21	−0.251 **	0.001
The total scale	79.8	10.636	85.2	7.296	−9.121 ***	0.000

Note: Experimental group n = 78, control group n = 78; $p < 0.05(*)$, $p < 0.01(**)$, $p < 0.001(***)$

Table 10. Analysis of covariance of environmental education in the experimental group and control group.

Unit	Source of Variation	Sum of Squares	Degree of Freedom	Mean Square	f Value	p-Value
(1) Environmental awareness	Group error	2.615 6.503	1 155	2.615 0.128	20.197 ***	0.000
(2) Environmental conceptual knowledge	Group error	3.239 5.530	1 155	3.239 0.189	28.170 ***	0.000
(3) Environmental values and attitudes	Group error	1.821 5.719	1 155	1.821 0.133	17.124 ***	0.000
(4) Environmental action skills	Group error	3.413 5.320	1 155	3.413 0.145	28.125 ***	0.000
(5) Environmental action experience	Group error	1.721 5.739	1 155	1.721 0.133	27.230 ***	0.000
The total scale	Group error	2.752 4.146	1 155	2.782 0.085	34.024 ***	0.000

Note: $p < 0.05(*)$, $p < 0.01(**)$, $p < 0.001(***)$

4.6. Analysis of System Satisfaction Questionnaire Results

Figure 10 presents the results according to the satisfaction of the experiment group students' use of the gamification environmental education apps' learning system for environmental education and learning activities. The system's interface design, system stability, system interaction, system teaching potential, and system entertainment may meet the environmental education learning needs and applicability of students from the experimental group. The overall average of the scale is 5.988: in terms of the system interface design (6.23), system stability (5.62), system interaction (5.58), system teaching potential (6.19), and system entertainment (6.32), 78 students from the experimental group are satisfied with the fluency and operation instruction of the environmental learning App system for environmental education learning. To integrate the gamification environmental education apps' learning system to help students observe the environment, this study focuses on five modules of environmental education: (1) environmental awareness and understanding of the environment; (2) environmental conceptual knowledge; (3) environmental values and attitudes; (4) environmental action skills; and (5) environmental action experience. A design of hands-on simulated learning activities, compared with environmental education learning methods in traditional teaching textbooks, can significantly improve students' environmental education learning outcome, which is consistent with the results of various studies [76–80].

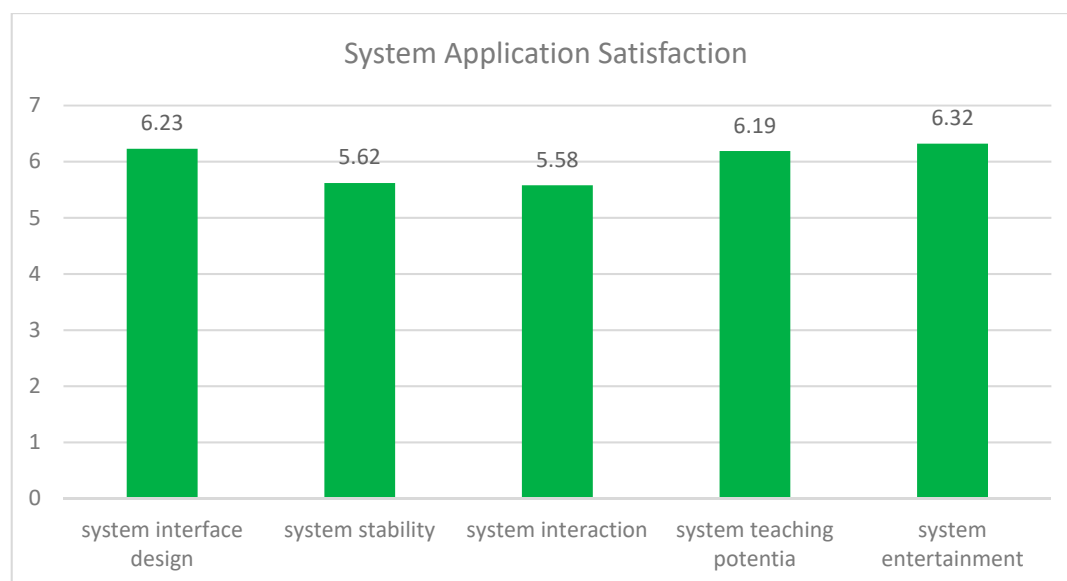


Figure 10. System application satisfaction.

5. Conclusions and Suggestions

5.1. Discussion

The results of this study show that the proposed four hypotheses are all supported in full and that the path coefficients of each hypothesis are highly significant.

The less useful, the more difficult to operate, and the more dissatisfaction towards service quality that gamification environmental education apps exhibit, the stronger the intention of switching will be.

The research hypotheses hold true and show that the less useful the gamification environmental education apps is, the less reluctant players will operate them. If the service quality cannot meet the needs of players, then it will be hard for them to use and further fire their intention to switch. This study is consistent with the findings of [81] and confirms the positive effect of PU and perceptual easiness on using intention. It also echoes Fornell's (1996) research, which proved that service quality has a positive impact on customer satisfaction and therefore believed that users would produce SB when they were not satisfied, while gamers would produce Push of migration when they felt that the service quality was inferior, or the system was not good. De Jong and Fawcett (1981) argued that people would migrate due to dissatisfaction [82].

The higher the players' subjective norms are and the stronger the attitude of transformation is, the stronger the intention of switching will be.

The social pressure felt when a player takes a particular course of action is the pressure imposed by other important persons or groups that push him to carry out that particular course of action. The stronger the players' subjective norms are, the more likely it is to motivate them to do what they intend to do. The results are consistent with those of Ajzen. Ajzen (1985) put forward the TPB and argued that subjective norms have an impact on consumers' purchasing intentions, and that behavioral attitudes and subjective norms would directly affect behavioral intentions [35].

The richer the information is and the lower the risks are regarding reputation, trust, and perception that a player obtains, the stronger the SI of the player will be.

In consumption decisions, Engel, Blackwell & Miniard (1993) deemed that getting rich information (or not getting) is one of the important factors that affect the intention of consumer behavior. If customers have prepared abundant useful information during the consumption decision-making

process, then their purchase attitudes would be positive [83]. The research results are consistent with those of Ennew et al. (2000). The impact of reputation on consumer behavior is greater than those of advertising and personal promotion and even occupies a vital position in the distribution of new products. Hence, for products with higher subjective norms, a higher IR and trust felt by service providers and customers with good reputation will promote stronger SIs [84].

The SI of gamification environmental education Apps has a significant positive impact on SB.

Behavioral intention is a tendency and refers to the positive or negative views or feelings users have towards new technology. Many previous studies [35,51], including the present one, have obtained empirical results, showing that behavioral intentions play an important role in actual behavior. Therefore, to enhance one's behavior or intention, one must either feel positive about one's behavior or perceive more normative pressure around oneself; and the more control one knows about the behavior, the greater is the intention that the behavior will be positive. Findings of Ajzen (1989) showed a direct positive correlation between intention and behavior. Davis (1986) also pointed out in the TAM study that attitudes, intentions, and effects of behaviors have positive relationships.

5.2. Conclusions

This study sets up a gamification environmental education App learning system, which not only helps to enhance students' learning outcome and interest in environmental education, but also stimulates them to integrate situations to simulate the intension of interactive learning and to promote reflection on contextual issues. The gamification environmental education App learning system can also meet the auxiliary learning needs of students in simulating environmental education. Students were satisfied with the gamification environmental education App system. This helps to satisfy the environmental education context simulation learning needs and applicability of students from the experimental group no matter in terms of system interface design, system stability, system interaction, system teaching potential, system entertainment, learning resources, multimedia teaching materials, and reflection issues. The total effect and explanatory power of model path coefficients ($R^2 = 0.626$) showed that the facets of SI have higher explanatory power of using SB, meaning that the whole model has good evaluation and predict ability. Hence, the behavioral intentions of this research model for gamification environmental education apps are not only predictive, but also provide a good overall model evaluation and research fit. In this regard, all the four hypotheses mentioned herein are significantly supported, meaning that if gamification environmental education apps are designed with PPM, then they will obtain a high degree of SI from users.

5.3. Academic and Practical Implications

5.3.1. Academic Implications

As there is an increasing number of research studies on topics related to gamification-assisted learning, this study proposes innovative predictive models for gamification environmental education apps and provides a reference for subsequent topics related to the design of gamification teaching materials. For migration SIs and behavior views of gamification environmental education apps, this study explores in-depth the design of Push, Pull, and Mooring of gamification environmental education apps as an important reference. The study finds that high SB indicates that players attach great importance to the interactive interface and service quality of gamification environmental education apps. Designers should give priority to improving the design standards of interfaces, such as user interface experience design and game player experience design. Sullivan (1999) pointed out that interactivity—that is, the interaction between information systems and users—also allows users to respond to information and content provided by information systems in the process. From the point of view of a system using satisfaction, the more "satisfied" people are with the information system, the lower their SI will be [41]. Hence, the results of this study can be used as a reference for future gamification environmental education App designing and the behavior theory of SIs.

5.3.2. Implications for Teaching Practice

(1) In the future, the gamification environmental education App learning system may be used to assist experiential learning of various subjects and curricula to explore their impact on the learning outcomes and learning interests of different learning objects. Gamification learning has been experimentally studied in natural sciences, education of historical monuments, arts education in museums, and engineering simulation learning to prove that it can enhance learning outcomes and interest in learning, echoing the findings of past scholars [78–80]. In the future, it may be applied in different learning fields and learning subjects to explore its role in promoting learning outcome and performance.

(2) Teachers can plan the learning content and activity design according to the needs of different learning situations to enhance the satisfaction of the gamification environmental education App learning system and to help experience the operational effectiveness of learning. However, the design of digital multimedia teaching materials, the exploration of sustainable development of simulation environment, and the design of teaching activities are the key elements to improve students' learning satisfaction. Therefore, in the future, efforts should be made to consider the learning connotation and activity design based on different experience learning scenarios to meet the exploration and experience learning needs.

(3) The interdisciplinary integration of the gamification environmental education App learning system's construction can be executed to enhance the self-learning and awareness consciousness of caring for the sustainable development of the environment. In the future, efforts should be made to integrate related interdisciplinary resources to design environmentally sustainable development learning systems and to promote students' ability to enact sustainable development of the environment during experience learning.

5.4. Research Limitations and Suggestions for Future Research

As the measurement of this study only uses the scale of literature sources, the PPM theory is adopted as the source of the questionnaire questions, and the quality research of expert interviews is not considered to understand whether there are any deficiencies in the theoretical constructs. The biggest limitation in quantitative surveys lies in the representativeness of the samples. In this regard, the issue of how to promote the factors of SI in gamification environmental education apps should be the top priority. The following is a list of several possible future research directions. (1) Factors affecting behavioral intentions of gamification environmental education apps can be complemented through greater in-depth qualitative interviews with industry experts to explore what are the key factors affecting the SI, thereby enhancing the predictive power of the model. (2) Future studies can conduct qualitative research interviews with experts to make up for the lack of quantitative research. It is further suggested that this model can be extended to include interference factors, such as gender and involvement, to observe whether the level of involvement has any regulated effect on the SI to set up limited resources in the interference variables to achieve maximum benefit. It will take a lot of time and cost to design and develop a serious educational game. Some of the cost must be consider such as teachers' acceptance and student teamwork, communication and social development.

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