A Study on Environmentally Sustainable Interaction Design Guided by User Behavior: Addressing Unsustainable Consumption

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Abstract. The global environmental crisis is getting more and more different from people's daily behavior. This paper studies how to build a mixed system of real and digital interaction by using interaction design. It looks for new ways to help people do good things for the environment. We use data pictures to show people's environmental responsibility. The study uses game fun, story design and mixed-reality technology to make a closed system. The system has four parts: understand, act, get feedback, talk with others. With technology, we turn the hard idea of environmental responsibility into real, easy things people can do. We solve the problem of too much unsustainable consumption. This study gives help and ways for many people to do good environmental behavior. It helps the environment stay healthy.

Keywords: Interaction design, environmental sustainability, unsustainable consumption, user behavior guidance

1. Introduction

Today, it is very hard to connect people's daily behavior with their environmental responsibility. This is a big problem for solving environmental issues. Scientists have data: people's daily consumption, especially unsustainable consumption, makes resources less and pollution worse. This happens through industry and supply chains. But most people do not know their own behavior hurts the environment. And there are no easy ways to help people turn their knowledge into real action.

Environmental sustainability is a very urgent problem. We need to solve it fast. Global warming is too serious: in 2024, the world's average temperature was 1.55°C higher than before the industrial age. This is the first time it goes over the 1.5°C goal from the Paris Agreement [1,2]. Household energy use and daily life also cause big problems. China's carbon emissions system shows: key areas like industry, building cities and towns, and transportation make over 95% of all emissions [3,4]. People's direct carbon emissions are small, but their energy use and consumption make big carbon emissions through supply chains. For example: China makes 19 million tons of plastic waste every year. Only 24% of this plastic is recycled. Single-use plastic is the biggest part [5]. In areas like retail, food delivery, and express delivery, people's consumption makes about 60% of all plastic waste [6,7].

Through this study, we want to fix one problem. People know they need to protect the environment. But they don't do it when they shop or live daily. We also want to find out how interaction design can help people turn their knowledge into action [8]. Now, many people tell others to protect the environment. But it doesn't work. Environmental problems are still getting worse. For example, 81.9% of people in a survey say they "want to sort trash". But the trash in cities still goes up 9% every year. In Beijing, it goes up 15–20%. Two years ago, 90% of people said they wanted to sort trash. Now, almost 10% fewer people actually do it. This shows: only telling people to protect the environment doesn't work. People know what to do, but they can't do it. All important numbers about green behavior go down [9].

Talking about "all humans" in a big way doesn't help people understand. Messages for one person often don't have clear steps or quick reminders. To make real change, people need to see the results of their actions. They need to know why changing their shopping and life habits is important. In short, we need a better way to connect what people know with what they do. We want interaction design to be this "bridge" to protect the environment. From a social view, interaction design is important when people consume too much. It can use technology to turn the hard-to-understand environmental crisis into real things people can see. It makes it easy for everyone to join in environmental protection [10]. It can also fix unfairness: the top 10% of people who use lots of resources and the bottom 50% of poor people have a big difference—4.2 to 77 times. We can use fun games to turn green actions into public rankings. This makes people in communities compete. It turns environmental protection from one person's choice into a common rule [11]. It can also make a "third space" between government rules and the market. This space connects one person's choices to big social systems. It helps change from small personal actions to big social changes. We don't just tell people who already care to act.

This study has many parts: help people understand the environment better, let everyone join easily, change people's cultural ideas, help different ways of environmental protection work together, and use technology well. This means interaction design is not just a tool. It is a social rule that changes how people and nature get along. It solves the problem of people knowing but not acting. It also answers the big question: how can people and nature live together in a time of technology? It changes values—from just changing behavior to changing our whole civilization.

2. The relationship between environmental sustainability and interaction design

2.1. Shared objectives

From the perspective of their final goals, interaction design and environmental sustainability are very similar. Both are a bridge between "people" and the "outside world" [12]. At the core, they have the same goal. They put people in the center and focus on long-term good results. Environmental sustainability wants fair use of resources for future generations and healthy ecosystems. Its goal is to meet people's current needs, without harming future generations' ability to meet their needs. It pays attention to nature-related goals like forest cover, water saving and carbon emission reduction, and hopes human society and the natural environment can live together in harmony. Interaction design, on the other hand, focuses on user experience and guiding user behavior. It aims to make easy, clear interfaces and smooth interaction processes to change how users act [13]. Both fields take "people" as the center, trying to balance personal needs and the common good of society.

This basic same point makes them work well together. Specifically, environmental sustainability gives new ideas to interaction design, helping it grow new branches. Interaction design can be a new tool to support environmental sustainability. The area of personal unsustainable consumption—this

paper's main topic—is one new example. Professor Lou Yongqi, Head of the College of Design and Innovation at Tongji University, said in his talk "Interaction Design for Sustainability" that interaction design needs to bring together four systems: nature, people, man-made things, and computer networks. Environmental sustainability can help interaction design in a complete way [14].

2.2. Empowering environmental sustainability through interaction design

New technologies like metaverse, AR, VR and XR can give long-term guidance to user behavior. Through information design and behavior incentives, these technologies put environmental ideas into people's daily life. They make things better, like clear information shows, better feedback systems, and better social communication. For example, in promoting conservation awareness, the "AR Digital Exploration of the Beauty of Kucha Culture" project at the Museum of Modern Chinese Journalism and Publishing allows visitors to use AR software to see moving murals. The murals show local nature and old wisdom. This brings old culture to life. It also quietly helps visitors care more about protecting old relics. It uses a closed loop of "see—understand—act"—this is exactly the value of interaction design supporting environmental protection [15].

Figure 1. Content framework of "AR Digital Exploration of the Beauty of Kucha Culture"

Figure 2. Example effects of the "AR Digital Exploration" experience

Similarly, AR technology helps a lot in environmental education. For example, Longjiang Road Primary School (Zhongliang Xiangyun Campus) in Chengdu held the "Beautiful China: Chuanwa in Action" environmental education activity with AR. The activity used an "Environmental Magic Scroll" with the 24 solar terms. It had four parts: "Blue Sky," "Clear Water," "Clean Land," and "Colorful World." It also had five parts like "learning knowledge" and "quiz games." Children used tablets and AR to play garbage-sorting games. They threw sandbags with different waste into the right bins. They also joined fun environmental quizzes. This made children more interested and learn faster. They learned environmental knowledge in a fun way and built environmental awareness [16].

Figure 3. Content framework of the "Beautiful China: Chuanwa in Action" AR activity

Figure 4. AR effects during the activity

Furthermore, interaction design's emotional design and moving stories, together with new technologies like big data feedback and the Internet of Things, can make people have better feelings about environmental protection. They will take part in environmental work for a long time. This is very important for environmental sustainability, because it needs long-term and steady effort.

3. Interaction design methods and logic for user behavior guidance

3.1. Gamification mechanisms

Gamification is a key tool to keep users taking part. It turns green behaviors into fun, task-like challenges through virtual experiences that make users feel involved. In level design, the system gives harder challenges step by step, based on how well users finish environmental tasks. For example, users start by checking in when they sort trash every day. Then they move on to simulating community environmental volunteer work. The reward and feedback system connects virtual and real life. It uses quick real rewards, achievement badges, public praise in social groups, competition rankings, and story-based progress to make users feel more involved in their roles [17].

During this process, the system asks users to enter their daily life habits. Then it makes a personal environmental plan for them. The main design problem is the difference between the system's best suggestions and the user's current habits. By breaking down this problem, the system turns big environmental goals into small daily tasks that are easy to finish. For example, for users who eat high-carbon food, the system suggests low-carbon recipes and starts a "carbon footprint reduction challenge." Solving this problem well is the system's main way to help users change their behavior. It is very important for changing how users act. Through constant positive feedback and challenge rewards, the system helps users slowly form sustainable living habits.

3.2. Nudge theory

Next, we briefly talk about interaction design as a tool to change behavior: from Nudge Theory to gamification design, and how technology can change how people take part in environmental

protection. Nudge Theory was made by Nobel Prize winners Thaler and Sunstein. It suggests designing ways for people to choose, which gently and without force, guide users to make better decisions [18]. Key rules include setting green behaviors as the default choice. For example, food delivery apps automatically choose "no disposable chopsticks" to make it easier for users to choose [19]. It also uses clear data displays to make users see the link between their behavior and results. For example, smart home systems show how much electricity a family uses in real time, compared with the community average. This helps users clearly see how their behavior affects the environment. It also shows group behavior data to use social influence. For example, social media shows friends' low-carbon life records, or fitness apps post local green travel rankings [20]. Our gamification framework uses and expands Nudge Theory in many ways. The system's default settings give priority to environmental options. For example, it automatically turns on energy-saving screens or signs users up for online environmental charity projects by default. Users get instant feedback through dynamic in-game data boards. When users finish environmental tasks, they see virtual forests grow or pollution numbers drop. At the social norm level, the system has community rankings and environmental achievement sharing functions. This lets users show their environmental contributions on social media. It creates a positive peer effect, which fully guides users to actively take part in green actions [21].

3.3. Design strategies for translating environmental behavior

Finally, this section proposes theoretical strategies for designing the translation of environmental awareness into behavior. First, goal setting should be gradual—especially in the early stages. The system should avoid immediately assigning highly challenging tasks or demanding drastic changes to users' existing lifestyles. Instead, goals should be small, simple, and easy to implement to ensure adoption. Narrative scenario construction is crucial for immersion and user stickiness, playing a decisive role in long-term engagement. Additionally, there should be some form of incentive (a "nudge") to ensure that users not only fulfill their social responsibility but also derive tangible personal benefits. By connecting the points system to the real world, users can exchange their accumulated points for real-life rewards as a return for reducing their unsustainable consumption behaviors [22].

Beyond online strategies, the "offline-to-online activation" mechanism is equally critical for the system's overall viability. We emphasize starting with offline interventions by designing a public interactive installation placed in parks or other locations frequently visited by local residents. Its distinctive appearance is intended to attract passersby to experience it. Equipped with VR/AR headsets and other interactive devices, the installation offers an engaging introduction that rewards users and initiates their journey into the gamified system. Under the dual motivation of gameplay and rewards, users enter the online loop we have designed. In addition, permanent points redemption stations ensure that after a period of online engagement, users will return to the physical facilities to redeem rewards and engage in new interactions with the public installation.

4. Exploring environmentally sustainable interaction design: addressing unsustainable consumption

4.1. Online game design concept

The game is made as a small program or app. It is easy to open and let people join at first. The game uses a view from above and is a sandbox simulation game about saving the environment. When

users open the game for the first time, they need to fill in a questionnaire about their life habits. The system gives a score based on their answers. This score decides the initial environment state of the game world. Players act as the government of a small island. They need to balance building the island and protecting the environment. Real-life user actions directly change the island's environment. If users do not improve their habits from the questionnaire, the island will get worse and die. The game will end. If users adopt better green habits, the island will keep growing. Players will get new stories, earn points, and exchange rewards. This is a direct use of Nudge Theory. It uses clear data pictures to push users to keep good habits. The main game play is about expanding the island. Each expansion needs points. Points come from better real-life habits. Bad habits give fewer points. Players must choose: stop growing, or use nature in bad ways to keep going. Players can also explore different scenes on the island freely. They can feel the environment they help build. The game is like "The Sims" but has more interaction. Users can also see the general environment performance of their community in the app. This also uses Nudge Theory. It makes users curious about the best users' island environments. It pushes users to visit offline interactive devices. At the same time, the community competition mechanism uses users' wish to compete.

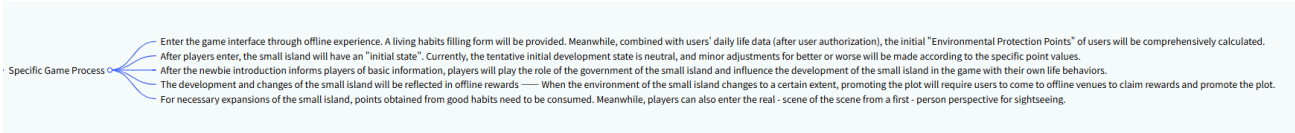

Figure 5. Online game flow

4.2. Offline public interactive installation design concept

The planned interactive device is a big, half-open triangle pavilion. Its three walls stand for three main parts of the harm from unsustainable consumption. The outside of the closed walls is see-through. Inside each wall, there are water plants in water tanks. When data shows water pollution gets worse, people will make the water in the tanks dirty. Visitors can see the harm to water plants clearly. One wall has a glass mirror shaped like a person. If data shows waste management gets worse or does not improve, garbage will be put inside the wall again and again. The garbage will cover the visitor's reflection. Visitors can feel the waste problem in a real way. The third wall has a small city in air. If air pollution gets worse, the air inside will turn dark. The small city will be covered in fog. It shows what bad air quality does.

These clear pictures with data follow and use Nudge Theory. They make environmental data easy to see and feel. The three walls show the whole environment state together. The top of the pavilion has solar panels. It makes its own energy. When the device starts, it is set to the worst environment state. As users improve their online actions, the device's look gets better. If users do not improve for a long time, the device goes back to a bad state. This makes users keep trying. Visitors can use VR to experience polluted environments—like beaches full of trash or cities in fog. They listen to educational stories. Then they scan a QR code to download the app. The device shows each user's initial "ecological contribution score". It pushes users to form better life habits. This connects offline use to online use smoothly. In the middle area, there is an AR interaction zone. It shows the island worlds of users with good habits or high ecological scores. Visitors can use AR devices to see and explore these virtual worlds. This area uses community competition to push other users to act.

4.3. Overall system operation flow

First, the public interactive installation has a noticeable look and big size. It draws people in the park to come over. At first, the three walls show very dirty, bad pollution. This makes people know environmental protection is urgent. It makes users feel they need to act. Visitors inside the installation watch introductions through 3D projection, VR and AR devices. They learn what the project is and why it matters. At the end of the introduction, they scan a QR code to download the environmental game app or open the small program. Then the user's use moves from offline to online. Players start the game by waking up on a small island as the new government leader. Because past people used too many natural resources, the island's environment is very bad: the water around is dirty, there are few trees, trash is everywhere, and people make a living from a mine and smelting factory. Players must make the virtual world better through real-life green actions. This is done by connecting with other phone apps—like getting reminders to take public transport or ride bikes instead of calling a car—and manually adding "green habit" scores every day. After playing for a while, users get a full review. It includes how their actions affect the interactive installation, their contribution to the local environment, rankings, and custom advice to improve their habits. Users who do well at protecting the environment get rewards. They must go back to the offline installation to get them. At some game steps, a message will show: "Protecting the environment is not one person's job. Please tell people around you about this program." If users share and get new people to join, the original user gets extra offline rewards. This is a "share and get rewards" way to get more people to join. If a user does not do well, the system gives custom advice and warnings to help them improve. When a user's real-life habits become very green, the online game shows a congratulations screen. Users can keep playing or choose to stop. Then new users can start their own cycle at the offline installation. This keeps the project's push going in a loop.

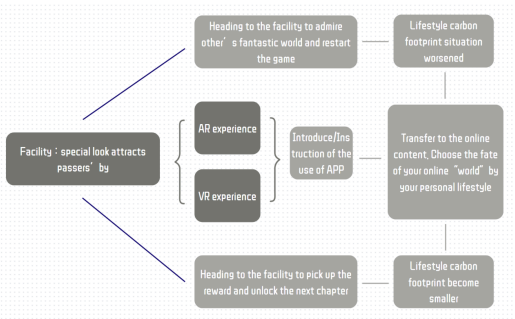

Figure 6. System operation flow

4.4. Significance of environmentally sustainable interaction design

This design uses new interaction technologies like AR and VR to support environmental protection. It also solves the main problem of "unsustainable consumption" that causes most environmental crises. Through a cycle of rewards that combines an online game and an offline public interactive installation, it gives new ways to help local communities around the installation protect the environment. Most importantly, it makes behavior change clear and keeps it going for a long time. The design turns big, hard-to-understand environmental problems into real, easy-to-do game experiences. Users can see their daily life data directly show how the virtual island's environment changes. This makes users clearly see the link between their actions and the environment. This "action–result" feedback loop fixes the old problem where environmental education is far and hard to understand. Also, the smooth connection of online and offline parts makes a multi-way,

expandable way to get more people to join in. This combination lets users start with offline experience, then go deep online, then spread to more people. It turns one person's actions into group actions. It makes environmental protection projects reach more people and have a bigger effect.

5. Conclusion and outlook

This study puts forward a new way to solve the big problem: people know they need to protect the environment, but they do not take action. We use interaction design to make a mixed system of virtual and real life. This system turns the big idea of environmental responsibility into real, easy things people can do. The online game and offline installation work together. They fully use the power of interaction design. They give users clear feedback about their daily consumption. They also help more people take green actions through community competition and rewards. In the future, as new technologies like the metaverse and the Internet of Things get better, we can do more things. We can combine data from different places. We can make better story designs for different countries. In the end, this can help people change how they consume in a deep way. It goes beyond just changing people's behavior. It helps build a new way for our whole society to live in a sustainable way.

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