Design of an Interactive Device for Children's Environmental Science Education on Plastic Pollution in Polar Regions Based on Open Source Programming Language

Yuning Fan 1*
1 School of Architecture and Art Design Hebei University of Technology, Tianjin, China
*Corresponding author’s e-mail: 184742@stu.hebut.edu.cn ; 1968324504@qq.com

Abstract. With open-source programming languages, Processing and Arduino, this device realizes man-machine interaction. It has the characteristics of a wide application range and a strong visual expression. Designers and artists can make their ideas real through Processing and Arduino. In recent years, plastic waste can be seen in every corner of the world, which means that raising people's awareness of environmental protection is urgently needed. Childhood is a key period for developing environmental awareness. In this paper, a popular science device related to environmental protection, taking children as the main target group, was designed and produced. The device provides a combination of technology and art to educate children about environmental enlightenment through external hardware configurations (switches, light sensing and pressure sensing) and on-screen images that show polar bears living in large amounts of plastic pollution.

1. Introduction

1.1. Source of polar white pollution
Since invented, plastic has been applied widely in various fields of life by means of unique and convenient performance. Polar white pollution is mainly from marine white pollution as well as plastic particles subsiding in the air. According to the United Nations data, more than 100 million tons of plastic was dumped into the global maritime space by August, 2019. Due to the sea and land distribution characteristics, white pollution is usually accumulated in the Northern Hemisphere. With the movement of ocean currents as well as the water exchange, a conveyor belt is formed by the floating white pollution. After reaching the Arctic, white pollution is difficult to flow due to the obstruction of the land and ice floe around the sea. At the same time, a lot of white pollution floats with the air. It moves a long distance in the atmosphere. It drops onto the ground along with rainfall or snowfall after reaching the Arctic. Therefore, the Arctic white pollution is mainly from the floating waste in the visible marine area as well as the plastic particles on the tiny ice surface.

1.2. Source of polar white pollution
According to the data from 2009 to 2019, the amount of white pollution in the Arctic Ocean grew by twenty times and the amount of waste rose from 346 pieces per square meter to 6333 pieces per square meter in the Arctic Ocean. In 2019, it was found through research that there were more than 12000 plastic particles per liter of sea ice, which was comparable to the highest pollution concentration near...
the urban coast. According to the test, the amount of plastic particles in the Arctic Ocean was the greatest in the world. The excessive plastic waste has affected the ecological environment seriously and even posed a threat to the lives of organisms in the Arctic.

According to the PAME Report on Marine Garbage in 2019, there were plastic particles in the bodies of some polar fish as well as blue mussels, snow crabs and starfishes. The preliminary research showed that the accumulation of a lot of plastic particles did harm to the digestive system, growth and reproduction of animals and even caused toxin accumulation in the bodies of animals [1]. There is still lack of attention and understanding of the severity of the Arctic white pollution in the world at present. As a result, it is urgent to enhance the public environmental awareness.

1.3. Source of polar white pollution
The Arctic is widely taken as part of the last primitive environment. The Svalbard "Doomsday" Seed Vault to preserve human hope is also located in the Svalbard Archipelago of the Arctic Circle (Norway). However, white pollution has caused adverse effect on the Arctic natural environment. According to scientific research in recent years, the Arctic plastic concentration has far exceeded people's imagination. It means that it is increasingly urgent to enhance the public environmental consciousness. Children are the future masters of the Earth. Environmental protection is inseparable from the efforts of contemporary people. In addition, it is necessary for the next generation to realize the importance and urgency of environmental protection fully. In the paper, it is hoped to show the life state of polar bears suffering from the Arctic white pollution in the form of interactive installation art according to the cognitive characteristics of children's growth. Build a relationship between the behavior of children and the settlement of the Arctic white pollution problem so as to carry out the environmental enlightenment education for children to improve their environmental awareness.

2. Materials and Methods
Children's growth characteristics: The environmental enlightenment interactive installation is designed for children aged 4 to 8. According to Jean Piaget's Cognitive-Developmental Theory, these children are in a chaotic state of undifferentiation between the subjective world and the material universe and short of essential knowledge. They know nothing about the physical and logical causality among things, resulting in the strong animism [2]. In addition, according to the Montessori Education Theory, children have the internal learning driving force as well as the exploration and absorption ability in the surrounding environment. They can establish their relationship with the environment according to the experience about exploring the environment [3]. In the paper, the gamification of the stereotyped environmental protection knowledge is mainly promoted on the basis of the two kinds of characteristics in the children growth period to guide children to carry out exploration and learning activities actively and happily.

Interactive installation art: The interactive installation art is an artistic installation based on the computer graphics technology, computer information collection and information processing and computing technology. Various information input and output carriers are taken as hardware facilities. The comprehensive material is used for the installation and production of a space scene as a practical platform. The human-computer interaction is taken as the form of expression [4].

Design elements: The design elements of the interactive installation for children are dominated by interactivity and integration. Due to interactivity, the traditional static aesthetics are broken through in the installation. Children can exchange information with the installation through interaction and endow the artistic installation with vitality, which is in line with the animistic psychology of children. Children are attracted in a more interesting way, which shortens the distance between children and art and strengthens children's understanding of the installation. Integration is equal to comprehensiveness. The interactive installation art is involved in many fields, such as computer language, psychology and audio-visual combination. It is integrated with other disciplines, which enhances the expressiveness and appeal of the interactive installation art. On the basis of the exploration on the psychology of
children, the channels for the information communication with children are established from various aspects to enrich the interactive experience.

3. Materials and Methods

3.1. Implementation of key technology
The interaction with children is based on the combination of the Arduino software platform and hardware facilities with the open source programming language of Processing as well as the external hardware configuration (such as the pressure sensitive button and the light configuration) and the screen image. The specific principle is aimed to capture the external signal input through the ultrasonic module and the pressure sensing module. After identification and analysis, feedback is made through the screen image transformation.

Arduino is an open source electronic prototype platform to apperceive the environment through a variety of sensors. The information perceived by sensors is processed and transmitted. Lighting, motors and other installations are controlled to feed back and influence the interactive experience environment. Processing is not only an important way of image representation and conversion, but also a kind of new computer language with the revolutionary prospect. More and more designers and artists adopt the processing program to get the sensory calculation results through computer programming and flexible language. It is aimed to explore the broad world of computer and expand the more artistic possibilities by combining the continuous development of technology.

3.2. Implementation of key technology
Ideas: White pollution is increasingly serious in the Arctic. The paper is aimed to cultivate children's environmental awareness through the interactive installation from the perspective of the environmental enlightenment education for children. Two children are guided to complete some interactive settings in cooperation by combining lighting, actions and interactive drawing on the basis of the programming technology of Processing and Arduino. Different feedback is made according to the screen. It is aimed to show the polar environment as well as the different life scenarios of polar bears before and after white pollution. In this way, the behavior of children is combined with the reduction of white pollution in the process of "saving polar bears" to enhance the sense of responsibility of children for environmental protection. As the two children further understand the world in the process of growth, the environmental protection idea buried in their childhood will be improved in practice so as to achieve the transformation from passive guidance to active actions and from unconscious games to conscious independent participation in environmental protection.

Installation form: The installation is mainly divided into two parts, including benches and screens. It is mainly blue and white, which corresponds to the Arctic. Benches and buttons are all made of the environment-friendly and degradable material. There are two benches including the left bench and the right bench for the interaction of two participants in operation. Each bench is equipped with three buttons corresponding to three different types of garbage. Participants need to eliminate garbage by pressing the same button in cooperation. Buttons are made of the frosted material. The base is made of the blue and white tie dyed fabrics, resulting in a feeling of polar iceberg. Formatting author names

The list of authors should be indented 25 mm to match the abstract. The style for the names is initials then surname, with a comma after all but the last two names, which are separated by ‘and’. Initials should not have full stops—for example A J Smith and not A. J. Smith. First names in full may be used if desired. If an author has additional information to appear as a footnote, such as a permanent address or to indicate that they are the corresponding author, the footnote should be entered after the surname.

According to the body size and psychological characteristics of children as well as their ergonomics and psychological attributes, the overall size of benches is 30cm × 12cm × 4cm. The overall installation height is 65cm. The button size is 7cm (The operation way of "beating" children like best). The pictures of the projection area are transformed by the gradual effect. It is showed that
with the efforts of participants, the Arctic is transformed gradually from environmental pollution to environmental improvement. The installation is equipped without simple black screens. The size can be adjusted according to the on-spot display screen. The bare wires and other components are wrapped with the wrapping paper. The popular science bulletin board and installation are also designed. The overall interactive installation effect is a combination between vision and touch to enrich the interactive experience of participants.

3.3. Installation connection and operation based on Processing and Arduino

Establishment of the information collection mechanism: The installation is mainly composed of the ultrasonic module and the switch module. Before the installation interaction, the beautiful environment of the Arctic and the living state of polar bears without white pollution were showed on the screen. After the approaching of participants was detected by the two ultrasonic sensors, the signal was transmitted to Arduino. When the screen image changed, the game started.

```cpp
void player1Detect(){
  digitalWrite(trigPin1,LOW);
  delayMicroseconds(2);
  digitalWrite(trigPin1,HIGH);
  delayMicroseconds(10);
  digitalWrite(trigPin1,LOW);
  cm1 = pulseIn(echoPin1,HIGH)/58.0;
  cm1 = (int(cm1*100.0))/100.0;
}

void loop() {
  player1Detect();
  player2Detect();
  if ((cm1>=20&&cm2<=20)||(cm1<=20&&cm2>=20)) {
    Serial.write("a");
  } else if (cm1<=20&&cm2<=20){
    Serial.write("b");
  }
}
```

Interactive operation: Five seconds after the beginning of the game, participants failed to operate it. When the garbage appeared on the increasingly dark screen with the increasingly weak saturation, it was implied that with the expansion of people's activity scope, the Arctic environment was polluted.
Then, the corresponding light emanated from the buttons on both sides in turn to guide children to press these buttons. The light went out after the left and right buttons corresponding to the garbage were pressed. Only in this way, could the garbage corresponding to the picture be eliminated. Through the cooperation of two people, buttons were pressed one by one to eliminate the garbage. The screen became bright and the saturation rose gradually. The original harmonious scene of the Arctic was recovered.

```java
void draw(){
    frameRate(20);
    image(bkg, 0, 0);
    image(bearHappy, 400, 200);
    fill(0,0,0,val);
    noStroke();
    rect(0,0,600,400);
    over();
    font();
    while(port.available()>0){
        char input = port.readChar();
        switch(input)
        {
            case 'a':
                image(output, 0, 0);
                image(bearSad, 400, 200);
                image(trash1, 200, 300);
                image(trash2, 200, 350);
                image(trash3, 150, 200);
                image(trash4, 100, 300);
                image(trash5, 100, 100);
                val=50;
                fill(0,0,0,val);
                noStroke();
                rect(0,0,600,400);
                case 'b':
                image(output, 0, 0);
                image(bearSad, 400, 200);
                image(trash1, 200, 300);
                image(trash2, 200, 350);
                image(trash3, 150, 200);
                image(trash4, 100, 300);
                image(trash5, 50, 200);
                image(trash6, 250, 250);
                image(trash7, 300, 300);
                image(trash8, 150, 250);
                image(trash9, 150, 150);
                image(trash10, 350, 350);
                val=80;
                fill(0,0,0,val);
                noStroke();
                rect(0,0,600,400);
                port.write("f");
        }
    }
}
```

Figure 3. Children interact with the device.

Results feedback: Before the end of the countdown, if children eliminated the corresponding amount of the garbage successfully, the rescue of polar bears was successful. After receiving the
corresponding information, the color image representing the victory would pop up in the processing screen image control module. In addition, thanks were expressed to children in the tone of polar bears to increase their sense of accomplishment. On the contrary, if the garbage is not successfully eliminated, the rescue failed. The color image representing the victory would appear in the processing screen image control module. The control screen of Processing would become monochrome and the picture that polar bears fainted due to the excessive white pollution was showed. Through the two different kinds of results, the possibility of interaction was increased so that children could become more deeply aware of the results of carrying out protective behavior or not. It was aimed to cultivate the environmental awareness of children.

```plaintext
    case e:
        val = 0;
        fill(0, 0, 0, val);
        noStroke();
        rect(0, 0, 600, 400);
        image(bearHappy, 400, 200);
        image(endpic, 200, 200);
        time = 30; }
    }

    void over() {
        time -= 1;
        timeshow = time / 20;
        if (time == 0) {
            image(bkg, 0, 0);
            image(bearSad, 400, 200);
            val = 90;
            fill(0, 0, 0, val);
            noStroke();
            rect(0, 0, 600, 400);
            stop();
        }
        void font() {
            textFont(font);
            fill(0);
            text(timeshow, 550, 50);
        }
```

Figure 4. Game result.

In the whole process, it is implied that we can reduce the Arctic pollution and rebuild the beautiful homeland for lovely polar bears in cooperation with each other. It is aimed to guide children to connect their own behavior with the Arctic white pollution. Moreover, the importance of cooperation to environmental protection is expounded. Through the image of polar bears, it is possible to better communicate with children and carry out the environmental enlightenment education for children.

Figure 5. Practice process.
3.4. Prospects
The interactive installation is aimed to show the seriousness of white pollution as well as the urgency of environmental protection in the Arctic in a more flexible and friendly way. It is of a certain insignificance of popularity and education from the perspective of the environmental enlightenment education for children. It plays an important enlightening role in the environmental protection education for children.

There are the more diversified form of interaction in interactive installation than in traditional artistic installations or popular science installations due to the addition of the programming language. It brings a new interactive experience in participatory art forms. In addition, the interactive installation is relatively in line with the growth characteristics of children. In the process of guiding children to play game, the unconscious environmental protection idea of children is cultivated. The environmental protection idea is transmitted to more social groups around children. The installation can be widely applied in kindergartens, science museums and polar exhibition halls to guide children to pay attention to the status of polar pollution and make them realize the importance and urgency of environmental protection from their childhood.

4. Conclusions
To sum up, the interactive installation art of the paper forms the interaction with children by "saving polar bears". It is aimed to call for the public to pay attention to the white pollution problem in the Arctic. It carries out the environmental enlightenment education for children and calls for the public to pay attention to the Arctic ecological environment. In addition, the thinking mode to combine technology, art and the environmental enlightenment education for children is showed to the public and some new design ideas are provided for the majority of designers. In the future, more designers will enter the field of interactive installation art, express social problems by writing codes and realize the natural integration of technology and art. It will also become a mainstream development direction of installation art in the background of rapid development of technology.

References
[1] Cen.S.(2018) Research progress on the status of micro white pollution as well as its impact on marine organisms. Environmental Monitoring and Forewarning. J. p. 1–11.
[2] Piaget.J.(1980). Children psychology. The Commercial Press (CP). China.
[3] Montessori,M.(2006). The Absorbent Mind. China Development Press. China.
[4] Xun.Y.(2018) Interactive installation -- New space for public art expression. Science & Technology Vision. J. p. 79–80.