Bio Sketchbook

an AI-assisted Sketching Partner for Children's Biodiversity Observational Learning

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ABSTRACT

Observational sketching is a common method to facilitate repeated observations that increase individual knowledge and awareness of biodiversity. However, this method presents a high barrier of entry for some novices, particularly young children. In this paper, we introduce Bio Sketchbook, a novice AI-assisted sketching partner to help children draw from observation and guide them to repeatedly observe different biological features. We describe our design process and goals, the interaction design of Bio Sketchbook, and results from a preliminary user study with six children. Our findings reveal Bio Sketchbook as a promising AI partner to encourage children to sketch from observation and gain biodiversity science education.

CCS CONCEPTS

• **Human-centered computing**; • **Interaction design**; • **Interaction design process and methods**;

KEYWORDS

Biodiversity science education, Observational learning, Interactive sketch tool, Co-creative system, Child-AI collaboration, Children

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1 INTRODUCTION

The profile of biodiversity reduction has been raised among scientists and on international political agendas. The Convention on Biological Diversity (CBD) [12] has positioned biodiversity as a critical asset to be protected to ensure our well-being and that of future generations. Although many laws and regulations have been enacted aiming to protect biodiversity, the lack of public education and awareness of biodiversity-related issues hinders the achievement of biodiversity conservation goals [13]. Thus, education plays an important role in influencing people's attitudes and behaviors toward biodiversity, especially those of children.

However, much of this education has been through the science curriculum. Children acquire knowledge from books rather than from observation, which leads to a disconnection with nature. Conversely, repeated observations of nature by children can increase their knowledge and awareness of biodiversity [6]. Observational sketching is one of the most important ways to encourage children to repeat their observations [3]. An observational sketch is a quick drawing that shows interesting features of something observed, which encourages participants to make repeated observations and comparisons [8]. However, young children are likely to have more experience drawing "from imagination" or memory rather than drawing what they see around them. For example, children often have difficulty grasping the morphology and perspective of drawn objects [2]. As exploration work, we built an artificial intelligence (AI) partner that collaborates with children to help them observe and sketch plants in nature and lowering the barrier for observational drawing.

In this paper, we propose Bio Sketchbook, an AI-assisted sketching partner for facilitating children's biodiversity observational sketching and learning. Bio Sketchbook is comprised of three main features: 1) identifying plants photographed by children and providing relevant knowledge about them; 2) transforming photographs into contour drawings, and 3) guide children to observe and draw different biological features. To build Bio Sketchbook, we developed a low-fi prototype and pursued design probe sessions with educators. Informed by these experiences, we made the iterated prototype focusing on allowing children the freedom to explore, encouraging repeated observations, reducing their drawing burden, and obtaining better self-motivation. We also conducted a preliminary user study with six children to understand the real user experience of Bio Sketchbook. The results showed that Bio

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Sketchbook is engaging and can encourage children to learn about biodiversity through observational sketching in nature.

In summary, our main contributions are as follows: 1) We present a novice sketching AI partner, Bio Sketchbook, to help children sketch from observation by generating contour drawings from photography and guide them to observe different biological features; 2) We describe our initial prototype, design probe sessions with educators, and the resulting design goals; 3) We conducted a preliminary user study within semi-structured interviews to examine the user experience of Bio Sketchbook.

2 RELATED WORK

In the field of Child-Computer Interaction (CCI), more and more researchers pay attention to children's outdoor activities. For example, Scratch Nodes [9] and GameBaker [1] combine traditional physical games with pervasive computational technologies and adopt a mixed entertainment way of interacting with the surrounding environment. However, a few works [15] focus on biodiversity education which is also a concern in child nature interactions. Chen et al. [5] designed a playful hybrid product for facilitating children's wildlife conservation education but limited to indoor. In this paper, we expand on existing biodiversity education research by applying observational sketching to the learning process. We encourage children to get out of the house and learn through repeated observations in nature.

However, observational sketching is difficult for children. In previous researches, children, work together with AI, can complete many tasks which are complex in their ages, such as music [4], auditory training [19], role-playing [18], and so on. They recognize AI as a friendly playmate, either "thinking with it" or "learning with it". Based on these findings, we proposed an AI partner to collaborate with children for facilitating observational sketching. The AI partner will help children observe and sketch different biological features.

There have been a variety of AI systems that focus on assisting sketching [11, 14]. For example, DrawMyPhoto [17] automatically parses a photograph into a step-by-step drawing tutorial to help a novice produce quality drawings. Upon these studies, we use AI to help children with line drawings and provide guidance and correction in coloring to reduce children's drawing burden and promote repeated observations in the observational sketching process.

3 DESIGN PROCESS AND GOALS

To design and build Bio Sketchbook, we firstly developed a low-fi prototype and then conducted design probe sessions with educators. Here, we describe the design process and the resulting design goals.

3.1 Low-fi prototype

We developed an initial, semi-functional prototype (Figure 1) with a Raspberry Pi 4B, an embedded thermal printer, a touchable display, a camera, a storage battery, and two buttons. Although this prototype's user interfaces are not interactable, we implemented the plant recognition and contour drawing generation functions. In this version, the generated contour drawings will be printed and colored with painting tools, such as markers, crayons, etc.

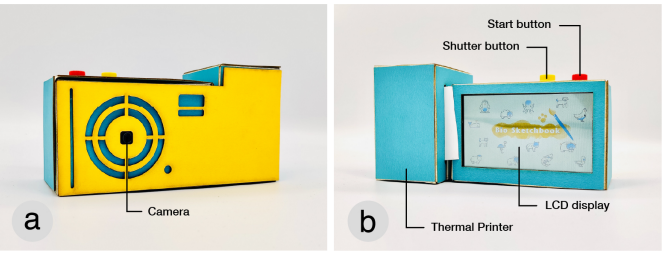

Figure 1: Low-fi prototype: (a) Front view. (b) Back view.

3.2 Design probe with educators

Once we had created initial, semi-functional prototypes, we solicited feedback from two groups of professional educators: science teachers (N=2, P1, and P2) and art teachers (N=2, P3, and P4). Each of them has at least five years' experience of working in children's education. Every session lasted roughly 60 minutes and included an introduction, a demonstration of the current prototype, and a semi-structured interview about educational experiences and their vision about the final prototype. Both groups of educators were generally positive about our prototype and made some suggestions which are as follows: 1) Both P1 and P2 recommended that the next generation prototype guide children observe and pay attention to the morphology, colors, textures, and living environments of different organisms; 2) P3 proposed that we design a collection mechanism, like Pokémon Go, to motivate children to get out of the house more; 3) P4 suggested that the final prototype can print on larger paper, or 4) allow children to use iPads (a line of tablet computers designed, developed, and marketed by Apple Inc.) for drawing without carrying painting tools with them.

3.3 Design goals

Informed by our own experiences building, using, and testing initial prototypes, our design probe sessions with educators, and relevant prior work, we synthesized the following key goals for an AI sketching partner aimed at children's biodiversity observational learning:

- Allow children to explore freely and lay little stress on learning tasks.
- Help children draw what they see around them and avoid relying on painting tools.
- Guide children to observe and draw different biological features, such as morphology, colors, textures, and living environments.
- Create a collecting mechanic to obtain better self-motivation.

4 BIO SKETCHBOOK

Based on the design goals concluded through the above research, we design Bio Sketchbook as an AI partner for children to explore and observe the real world. Considering portability, we deployed it on a tablet. Besides, in order to reduce the learning burden of children, we do not set learning tasks; instead, we encourage children to explore freely in nature. We also seek to leverage new AI-powered technologies to help children draw from observation and learn about various plants.

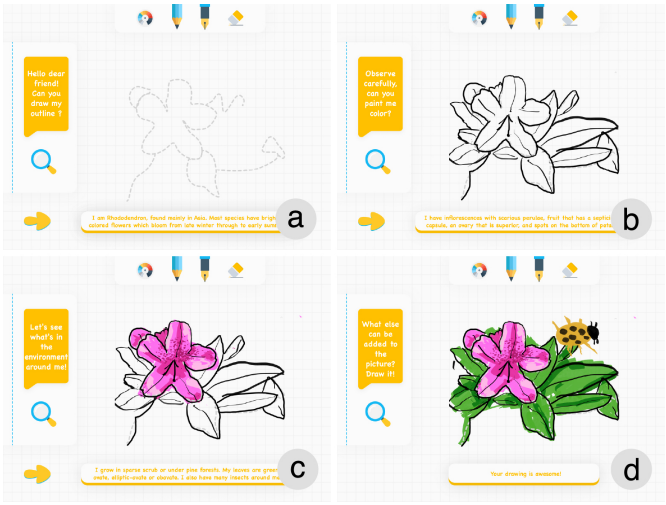

Figure 2: Observational sketching with Bio Sketchbook: (a) Bio Sketchbook generates a contour drawing. (b) The child observes the plant's morphology and refines the line drawing. (c) The child discerns the plant's color and texture and draws. (d) The child watches the living environment and polishes the whole painting.

4.1 Interactions

4.1.1 Find and capture. After the starting page, the child will find a monitor frame in the center and a shutter button on the right side. Bio Sketchbook will display the plant's name below the monitor frame on recognizing the main plant in the lens. Then the child can click the shutter button on the right to take a picture of the plant in front of them.

4.1.2 Observe and draw. After the child takes a picture and confirms the drawing, Bio Sketchbook will transform this picture into a contour drawing shown on the drawing page (Figure 2a). On this page, the child needs to observe different plant features and draw them with the guidance of Bio Sketchbook (Figure 3b). First, the child needs to supplement and refine the line drawing (Figure 2b) while Bio Sketchbook describes the organism's morphological features. After that, the child observes the plant's color and texture while coloring in the line drawing (Figure 2c). Bio Sketchbook will compare the color of the child's drawing with the corresponding area of the picture and alert the child if he or she makes a drawing error. Finally, Bio Sketchbook will guide the child to observe the living environment and allow the child to polish the whole painting (Figure 2d). Throughout the process, children can click on the right arrow icon and go to every next step. A subtitle with voice prompts telling the child about biology appears at the bottom of the canvas.

4.1.3 Learn and review. After painting, the plant's detailed information from Google's Knowledge Graph [20] will be displayed (Figure 3c). The child can learn more on this page. The drawing will be collected on the Bio-Illustrated book page where contains all the user's captures and illustrations. It provides a collection mechanism to encourage children to observe various plants.

4.2 Implementation

Bio Sketchbook is composed of a front-end web page and a backend server with data processing models, including a detection classification model and a sketch generator model. Bio Sketchbook gets the plant's classification in real-time and transforms pictures into contour drawings. We use a ResNet50-V2 [7] model for detection and classification, which is pretrained with iNaturalist2017 [16] datasets. The generator model is called Photo-Sketching [10], which can generate boundary-like drawings that capture the visual scene's outline. We also use Google's Knowledge Graph [20] to provide children with a wide range of biological information.

5 PRELIMINARY USER STUDY

To confirm how children play with Bio Sketchbook and how this AI partner impacts children's knowledge of biodiversity science in the real context, we conducted a preliminary user study within a semi-structured interview. This study recruited six children aged 5-8 years (two males and four females, mean age = 6.50, SD = 1.26) from a neighborhood school. Every participant has learned some knowledge about biodiversity through science curriculums and has studied painting. The whole process was recorded with the consent of the children's parents.

5.1 Procedure

To promote participants' connection with nature, we conducted this study in a botanical park. The session was started by giving a demonstration and idea of Bio Sketchbook to children for 10 minutes. In the next 30 minutes, children were given a tablet running Bio Sketchbook application to explore various plants and do sketches. We recorded children's using process and interactions with Bio Sketchbook. After finishing using session, we conducted semi-structured interviews with children to have more qualitative ideas of Bio Sketchbook. The semi-structured interviews focus on three topics: 1) Their relationship with Bio Sketchbook; 2) Knowledge about the plants they have explored; 3) Difficulties they encountered when interacting with Bio Sketchbook.

5.2 Result

We conducted a semi-structured interview with the participants (Figure 4a). During this experiment, four children completed one observational drawing, and two others completed two. Figure 4b shows two of the observational drawings created by these children when using Bio Sketchbook.

All the participants showed a high willingness to use Bio Sketchbook, but they offered different tendencies to use it. C2 liked to take the tablet around to identify various plants but rarely entered the painting interface. When C2 was asked about his relationship with Bio Sketchbook, he said, "It's like a tool. It told me what the plant in front of me is." However, C3 and C5 started painting as soon as they found a plant and saw it as more of an art teacher because "it taught me how to draw and corrected my mistakes".

When we showed the participants different pictures of plants and asked them to find their observation plants, all participants were able to find the correct. We also asked some questions about biological characteristics of the plants that the children were observing. All children can answer the questions well using what they

Figure 3: Usage steps of Bio Sketchbook: (a) Find and capture. (b) Observe and draw. (c) Learn and review.

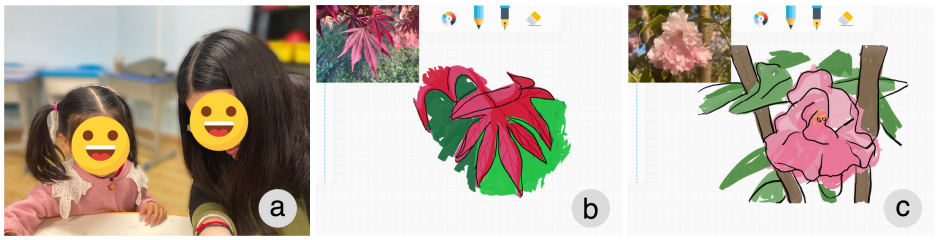

Figure 4: (a) Interview with users. (b-c) Examples of the observational drawings created by participants.

have learned in Bio Sketchbook. There were even three children (C1, C2 and C6) who were able to gain new insights from their observations. For example, C1 said, "Purple azaleas have small red spots but pink azaleas do not have such spots."

During our observations, we identified a number of difficulties that children encountered in using the Bio Sketchbook. For example, some children's hands were too small to grasp the tablet. C4 also complained to us that we provided too few brushes and she wanted crayons. Besides, C5 told us that the description of the plant in Bio Sketchbook did not match what she observed. This may be due to the fact that the flowers are in different stages of growth.

In general, our findings reveal Bio Sketchbook as a promising partner to encourage children to sketch from observation and gain biodiversity science knowledge.

6 CONCLUSION AND FUTURE WORK

We presented the initial prototype design of Bio Sketchbook and conducted design probes with science teachers and art teachers. After that, we concluded our design goals and developed the iterated prototype. We design Bio Sketchbook as an AI partner to facilitate children's biodiversity learning based on observational sketching. In our preliminary user study, we found that Bio Sketchbook is engaging, showing its potential as a platform for motivating children to observe and learn different plants in nature.

These experiences also suggest several avenues for future technical work. First, we need to improve our recognition algorithm to identify plants at different growth stages. Besides, more drawing tools should be provided, catering to different drawing needs of children. We also need to improve the entire system's interpretability and further deepen the collaboration between AI and children.

The next step for user study will be to gather more quantitative data and analyze children's task load as well as the system usability. Also, we need to conduct a comparative experiment to compare children's effects on learning with or without our system. Finally, more research is required to examine how children would use Bio Sketchbook for longer periods and explore how the relationship between AI and children would develop.

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