Playscape

Cultivating children's connection with nature through an outdoor play system

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1. Introduction

Our capstone team, Playscape, aims to cultivate children's connection with nature through an outdoor play experience. Research indicates that children globally are increasingly disconnected from nature, spending more time indoors. This lack of connection with nature is evident in reduced species literacy and a cultural shift away from nature-focused content in media and popular culture. Factors contributing to this disconnect include technological distractions, reduced emphasis on outdoor play in schools, and urbanization limiting access to green spaces. This lack of nature connection is concerning because it's linked to reduced well-being and less engagement in sustainable behaviors. Nature-connected individuals tend to be happier and more likely to support environmental conservation. Given the rapid decline in biodiversity due to human activities, fostering nature connection in children is crucial for promoting sustainability. What's good is that nature connectedness can be increased, and outdoor play can help get children engaged with nature and connected.

Our approach features an iterative design process and includes a literature review, interviews with parents and experts, a competitive analysis on existing products, observational studies, and usability testing. We landed on an outdoor play system solution that invites children to learn more about local biodiversity while engaging in playful learning. Playscape consists of an outdoor interactive installation and an accompanying digital application, focused on educational and sensory experiences.

2. Background

Research has suggested that children today, globally, have a disconnect with nature (Soga & Gaston, 2016; Kleiner et al., 2017). The term "nature connectedness" refers to an individual's subjective sense of their relationship with the natural world (Martin et al., 2020). A survey of 12,000 adults and children in the United States showed that many people have lost a close connection with nature (Kleiner et al., 2017). Specifically, parents of 8 to 12 year old children said that their children spend three times as many hours with computers and televisions each week as they do playing outside, and that parents are concerned their children are "unacquainted with the simple enjoyment of being outdoors" (Kleiner et al., 2017).

As part of this disconnect from nature, children worldwide have a considerable gap in species literacy (Hooykaas et al., 2019). One study from the Netherlands showed that children aged 9-10 were only able to identify 35% of common, native species correctly (Hooykaas et al., 2019). In Germany, a study with 11-13 year olds found that there has been a 15% decline in species identification in the last decade, and animals like birds and reptiles were generally unknown (Gerl et al., 2021). A poll done with 1,000 British children revealed that 83 percent of children between the ages of five and 16 did not know what a

bumblebee looks, and 65 percent were not able to identify a blue tit, which is a bird species commonly found in British gardens (McCarthy, 2019). Perhaps even more concerning, in 2017, researchers from Cambridge University surveyed children and found that children over the age of eight were “substantially better” at identifying Pokémon “species” than “organisms such as oak trees or badgers” (Jenkins, 2019). There was around 80% accuracy for Pokémon, but less than 50% for real species (Jenkins, 2019).

This disconnect from nature can also be seen in today’s culture. In recent years there has been a cultural shift away from nature, where references to nature have been declining in books, lyrics, and stories (Kesebir, 2017). After the 1950’s, there has been a significant decline in nature features in popular culture, with significantly less features today than it did in the first half of the 20th century (Kesebir, 2017). An example of this is that for every three nature-related words in the popular songs of the 1950s, today there is only slightly more than one (Kesebir, 2017). Additionally, a study examined disney films in the last 70 years and found a steady decline in the number of outdoor scenes with green nature as well as the animal species richness (Prévot-Julliard, et al., 2015). In sum, this research shows that there has been a shift in how society views nature as it is not as commonly shown or featured in pop culture and media as it once was, reflecting this increased disconnect with nature.

Looking specifically at children, there's a big reason for why there is this increased disconnect with nature. Children today are generally spending less time outside. In a wide context, a survey indicates that American children now spend 35% less time engaging in unstructured outdoor play than their parents did (Robinson, 2020). According to the survey, 65% of parents reported daily outdoor play during their childhood, whereas only 30% of their children do the same today (Robinson, 2020). Furthermore, the survey reveals a concerning trend, with almost one in five children today playing outside only once a week or less. With less time spent outdoors, children are not spending as much time in nature. There are several reasons for why children are not spending time outdoors. First, with the rise of technology, more kids are spending time on their devices and staying inside (Kleiner et al., 2017). Additionally, schools are not encouraging engagement with nature and over the last decade, play has become less valued in the school systems as they have put more emphasis on academic curriculum (Kleiner et al., 2017; Neuman & Freschi, 2023). Finally, changes in the urban environment are also creating this decline. Urbanization has been shown to significantly reduce the frequency of direct experiences of nature (Soga et al., 2017). Less abundant parks, playgrounds, and green spaces also create barriers for kids going outside (Milteer et al, 2012; North, 2023).

Children not having a connection with nature is a problem because there are benefits in having this connection. Nature connectedness has been shown to increase children’s overall wellbeing (Capaldi et al., 2014; Kesebir, 2017). Specifically, people that are connected to nature experience more positive affect, vitality, and life satisfaction compared to those less connected to nature (Capaldi et al., 2014). Thus being connected to nature is

tied to happiness. In addition to having a positive wellbeing, having a connectedness with nature has been shown to be linked with sustainable behaviors (Hosaka et al., 2017; Barrera-Hernández et al., 2020; Chawla, 2020; Hamlin & Richardson, 2022; Price, 2022). In a study that looked at children with the average age of around 10, it was found that connectedness to nature was considered as a determinant of sustainable behavior, where children who perceived themselves as more connected to nature tended to perform more sustainable behaviors (Barrera-Hernández et al., 2020). Relatedly, additional research has shown that children with higher measures of nature connection show greater willingness to commit to conserving nature (Chawla, 2020). Finally, it has been found that connection with nature in childhood is correlated with more positive attitudes towards animals and pro-environmental behavior in adulthood (Hosaka et al., 2017; Price, 2022). Therefore, having a connectedness with nature not only is important for children's overall wellbeing, but also is associated with sustainability and conservation efforts which are important for the world.

We know that biodiversity is declining at a high rate due to habitat destruction, overexploitation of natural resources, pollution, and climate change (Hooykaas et al., 2019; Preso, 2022). Roughly 1 million species already are at risk of extinction, and nearly 40 percent of all species on Earth may be threatened with or driven to extinction by the year 2100 (Preso, 2022). This is concerning because biodiversity is important for maintaining the ecosystem's health as well as for human society (Rafferty, 2024). An example of this is that with biodiversity loss, it would threaten food security (Rafferty, 2024). There are actions we can take to help combat biodiversity loss. Sustainable behaviors by humans such as protecting habitats, conserving water, recycling, using clean modes of transportation to reduce pollution levels, and saving energy, can help to protect biodiversity (Rafferty, 2024; Klorane Botanical Foundation, 2024; The Royal Society, 2024).

With biodiversity loss declining, children are expected to see thousands of species disappear in their lifetime (Bradshaw & Stroni, 2024); however, this can be mitigated through sustainability and conservation efforts. From the research we know that connectedness to nature can increase sustainable behaviors and conserving nature. Children today lack a connectedness to nature, however it is possible to increase one's connectedness to nature. Research has shown that contact and engagement with nature can increase nature connectedness (Sheffield et al., 2022). Furthermore, outdoor play has been found to be successful in getting children to engage with nature (Chawla, 2020). Thus, for our capstone project, our goal is to create opportunities for children to engage with nature, in order to increase their connectedness with it.

3. Methods

We conducted multiple methods for this research project. First, we conducted a literature review to explore benefits of outdoor play, as well as different forms of play. Additionally, we looked into physical and digital forms of solutions.

We also conducted semi-structured interviews with parents who had children ages 3 to 13 years old. We recruited participants through word of mouth. These interviews were conducted over Zoom, and each session lasted approximately 30 minutes. During each interview, we asked a series of questions around childrens' current outdoor activities, their favorite outdoor activities, challenges and barriers they face that may prevent them from playing outside, technological influences, and possible solutions and suggestions for increased outdoor play. Below in Figure 1 is a table showing each participant, their parental role, the number of children they have, and the age and gender of each of their children. Our study protocol was approved by UC Berkeley's institutional review board (IRB).

Participant Number	**Parent Role**	**Number of Children**	**Age and Gender of Children**
P1	Mother	3	9, girl; 9, girl; 4, boy;
P2	Father	1	3, girl
P3	Father	2	8, girl; 4, boy
P4	Father	2	9, girl; 5, girl
P5	Mother	2	4, boy; 2, girl

Figure 1. Table of parent participants who took part in semi-structured interviews.

In addition to interviews with parents, we conducted a series of design thinking workshops to consider what an outdoor play solution could look like. These workshops totaled to 5 sessions and took place over the course of one month. Each session lasted two hours and included popular design thinking exercises, sketching, prototyping, and iteration. We reached out to domain experts in biodiversity at UC Berkeley and UC Berkeley-affiliated institutions and conducted interviews to better understand the subject area of biodiversity and understand relevant information to share with children. Lastly, we conducted concept testing of possible prototypes amongst a handful of peers, and we also conducted a

competitive analysis of current digital applications and products that focus on outdoor play experiences and nature education.

4. Execution

4.1 Literature review

We conducted a literature review to investigate what would make a successful solution. For our solution, we wanted to create outdoor play opportunities as it's been shown to be successful in engaging kids with nature. We researched in more depth about outdoor play and its benefits, as well as different forms of play. Additionally, we looked into what form the solution should take, physical or digital. In sum, we found support for sensory play and playful learning, as well as support for both a physical and digital solution.

The full literature review can be found in the appendix.

4.2 Semi-Structured Interviews with Parents

As previously mentioned, in order to better understand childrens' relationships with outdoor play, we recruited five participants who were parents of children ages 3 to 13 years old and conducted semi-structured interviews. Most participants shared that their children do spend time outside and in nature; however, this time spent outdoors is filled with a variety of activities. Some children play on playgrounds, ride on scooters, play games during recess, participate in outdoor sports, and socialize with friends.

Some of the barriers to outdoor play that came up during interviews with parents included weather and climate conditions, as factors like lack of daylight and rain prevented some parents from letting their children spend more time outdoors. Other barriers included concerns about safety and busy schedules filled with extracurricular activities, birthday parties, and other parent obligations.

When asked about their ideal approaches, priorities, and needs around encouraging more outdoor time amongst their children, parents shared a few perspectives. One was that having the allure of an activity helps when trying to motivate a child to play outside. Another need was a way to teach children about nature and respecting nature, especially in areas that are more developed or that do not have access to nature and outdoor recreation activities. Lastly, one need was having a way for children to play outside while still staying close to home due to safety concerns.

4.3 Expert Interviews and Correspondence

We conducted one interview with a UC Berkeley faculty member, who is a domain expert on biodiversity. During this interview, we asked questions about their perspectives on biodiversity education, crucial pieces of information to share with younger populations, and experiences with outdoor education. Some of the key learnings from this conversation included focusing on local species, such as the peregrine falcon, considering the purpose and durability of an installation and the types of messages an installation could present, and lastly, ensuring that all species have intrinsic value, their ecosystem benefits, and how closely interdependent they are.

We also conducted an interview with a staff member at a UC Berkeley affiliated institution focusing on fostering science education among children in order to better understand how children engage in nature play and learning activities. We asked similar questions about their perspectives on biodiversity education and key considerations for building a physical and digital learning experience. Some of the takeaways from this conversation included a better understanding of current approaches to biodiversity and nature education geared towards children. This included practices like nature journaling, silent observation, nature scavenger hunts, and general nature play where children use their senses to engage with the environment. We also learned about some of the ways in which technology can be both of assistance and a hindrance to nature education. For example, iPads can be a more tactile surface for children to utilize during nature observations; however, when children are outside, they experience glares on these devices from the sun and thus make seeing content and pictures more difficult.

Additionally, we were in correspondence with a handful of UC Berkeley faculty members with domain expertise in biodiversity, ecology, and nature education, who shared on-campus resources, prior work on biodiversity education, and opportunities for more engagement.

4.4 Design Process

In addition to our literature review and interviews, our project team also conducted a series of design thinking workshops to consider the different ways in which we might approach a prototype–one that could serve as an interactive play experience for children while educating them about biodiversity. We considered the form of this play experience (e.g. installation, portable object(s), digital application, etc.). We also explored what aspects of biodiversity to focus on, such as plant species, animal species, interdependencies of species, and ecosystems. Additionally, we ideated the types of interactions the play experience would include. For example, we considered different types of senses to engage during the play experience. Lastly, we also created a variety of sketches of both digital and physical versions of a potential play experience.

4.5 Concept Testing

In order to converge on a prototype, we conducted concept testing with a handful of peers, who were primarily user experience researchers and designers at UC Berkeley. During each concept testing session, we presented five different concepts for a physical version of a play experience (see Figures 2 and 3). After showing sketches and storyboards of each concept, we asked each participant to share aspects of the concept that they liked or found enjoyable, aspects that they found confusing or frustrating, and lastly, a rating between 1 to 5 (where 1 meant that they would not engage with the concept, and 5 meant that they would definitely engage with the concept) and their reasoning. At the end of the session, we also asked each participant to share which concepts they felt were the most and least enticing as well as any other changes they would have liked to see with any of the concepts.

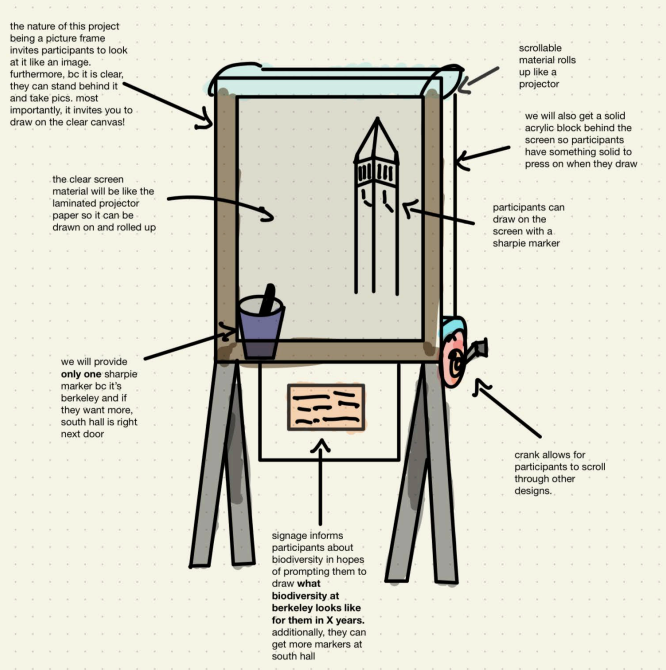


Figure 2: Infinite scroll concept test sketch.

Figure 3: Animated music box concept test sketch.

Some aspects of the concepts that participants particularly enjoyed and wanted included observing the surrounding environment through a clear, see-through screen, being able to easily approach the designs, being able to see others' contributions, interacting with the design through sound and audio components, and wanting clear, straightforward instructions. Participants also noted some of the challenging and confusing aspects of the presented concepts. This included fears around too much open-endedness and complex topics, such as the future, within concepts, worry about the variance in drawing skills, and concern about not being able to reset the experience after they are finished interacting. Additionally, some participants mentioned that the connection between the audio and visual elements of the design should be clear.

4.6 Competitive Analysis

We carried out a competitive analysis of various digital applications and products that focused on outdoor play and nature education. Specifically, we focused on outdoor exploration apps, nature identification apps, and traditional nature education formats. Across each category, we identified their strengths, gaps, how playful or educational they are, and how mobile or static they are. See Figure 4 for a table that summarizes our findings.

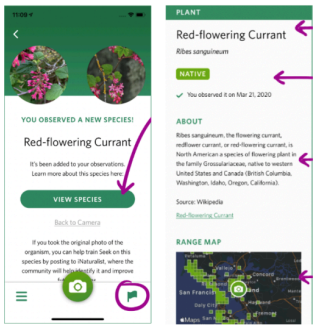
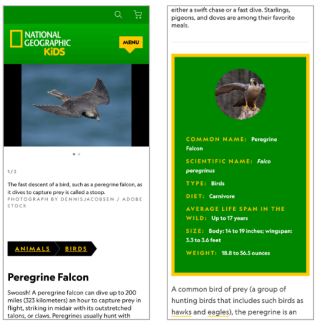
	Pokémon Go	seek by iNaturalist	Nat Geo Kids
Product Descriptions	Pokémon Go is an augmented reality mobile game, part of the Pokémon franchise. It uses mobile devices with GPS to locte, capture, train, and battle virtual Pokémon, which appear as if they are in the player's real-world location	The Seek app uses image recognition technology to identify fungi, plants, and animals around you; just point the Seek camera at any organism and it will start working to identify it.	National Geographic Kids is a children's magazine published by the National Geographic Society. Currently, it has a website with a section on Animals
Product Screenshot(s)			
Type of Interaction	**Mobile** ⟷ **Stationary** **Playful** ⟷ **Educational**		
Strength(s)	• Strong nostalgia factor • Gamified outdoors • Incentives (rewards, levels)	• Incentives (challenges/badge system) • Social/community aspect • Crowd sourced, citizen scientist approach	• Comprehensive • Factual
Weakness(es)	• Limited educational value • Lacks intention • Safety considerations (random spawning, location awareness)	• No highlighting of each life stage in cycle -> only user submitted photos • Not kid friendly & content heavy • Ex: Shows 7 taxonomies each	• Not interactive -> passive information • Games = general, not animal specific • Text heavy -> not child friendly • Photos mostly of adult stage

Figure 4. Competitive analysis table of digital applications and products that focus on outdoor play and nature education.

5. Prototypes

5.1 Overview

For our solution, we developed an outdoor play system focused on educational and sensory experiences that invites children to learn more about local biodiversity, as a way to cultivate children's connectedness with nature. It targets children aged 7-13 because this age range is consistent with previous research that showed children around these ages lack a connectedness to nature. Our solution consists of an outdoor interactive installation and

an accompanying digital application. We decided to have a physical installation because we have seen success in other installations, particularly the Little Free Library, and we wanted to have an installation that was intertwined within the existing environment for children to come across. It pairs with a digital app prototype in which we decided to have based on seeing research that app-based solutions can enrich a child's sense of exploration of the environment and foster deeper connections to nature (McGlynn-Stewart, Maguire, Mogyorodi, 2020).

For choosing the species to highlight in our solution, we took the recommendation from a campus biodiversity expert to showcase a peregrine falcon, fox squirrel, and mule deer, which can be seen around campus. Our idea to pursue nature and biodiversity as part of our solution is further validated by UC Berkeley's Campus Biodiversity Report which states how UC Berkeley is currently trying to conserve and enhance biodiversity around campus. Furthermore, the campus hopes to "integrate biodiversity on campus and within the broader community", enhance student learning related to biodiversity, and encourage students to spearhead projects related to this initiative.

5.2 Installation Prototype

The physical frame installation is a starting point for children to explore the rich biodiversity that lies outside. Upon its discovery, a visitor of the installation will see how it blends in with the natural surroundings due to the high grade fir wood extended by pieces of spruce and yellow pine as seen in Figure 5. As a physical frame installation, the location is intentional as it serves as a snapshot of the local flora, fauna, landscape, and any animals within the view. While it can be obvious to take a look outside, the installation aids in framing that view, capturing a moment that may have been once overlooked. In an age where portable, digital devices take up our attention, the fixed view of this low-tech system enables visitors to observe the beauty in the mundane, reconnecting with the world around them.

Figure 5: Playscape frame and signage at Lawrence Hall of Science's Outdoor Nature Lab.

Building the physical installation requires two major components. The first is the infrastructure, which consists of several pieces of lumber, screws, plexiglass, and an acetate overlay to display on the clear plexiglass. The wood was assembled in the design of an easel to invite children to draw on the clear plexiglass. We supply markers to assist with that process. Furthermore, the frame shape of the installation serves an aesthetic purpose as a photo-op for passersby who want to stand behind the frame and snap a picture of the landscape.

The second component is the digital sensory experience. On the frame, there are three sensors that a visitor can press and apply force on to emit noises. These three noises correspond to an animal that is on display on the frame. Artifacts of nature (twigs for the falcon, tree bark for the squirrel, and leaves for the deer) provide a hint as to which animal it represents. Additionally, green LEDs light up next to the corresponding animal. To accomplish this effect, we utilized three force sensing resistors (FSRs) wired up to an Arduino Uno microcontroller that was powered by a 9V battery. Each FSR is incorporated into a voltage divider circuit, interfaced with the Arduino Uno. The 1k ohm resistors

(brown-black-red-gold) serve as fixed resistors in series with the FSRs, connecting to the ground. This setup allows the Arduino to measure changes in resistance as changes in voltage at the analog input pins, corresponding to the force applied to the FSRs. The Arduino Uno registers the force input from the person interacting with the FSR, and if the input exceeds a threshold defined in the Arduino sketch, it will trigger a sound. The sketch can be found in the Appendix section of this report as Appendix 1. This sound is accomplished by connecting the Arduino to a DFPlayer Mini, a small module that enables audio files to be outputted. This module is linked to an LM386 audio amplifier that amplifies the sound intensity when projected through a coaxial speaker. No circuit schematic will be provided but an image of the circuitry can be viewed in the Appendix section of the report as Appendix 2.

Figure 6: Close-up view of the clear plexiglass frame on the Playscape installation.

Through this specific clear plexiglass frame, observers will notice three animals: a peregrine falcon, a fox squirrel, and a mule deer as shown in Figure 6. We chose these three animals as part of a larger initiative to expand the awareness of what animals cohabitate with us in the outdoors. While an observer may know they exist, visualizing the invisible can bring light to the vibrancy of their local biodiversity. Focusing on the falcon, squirrel, and deer, these three animals are some of the animals that can be witnessed around the local

Berkeley area, from South Hall all the way up to the Lawrence Hall of Science. In a future where this initiative is to be expanded, we can expect more frames to showcase other animals native to the respective local area. As of this current iteration, we designed a digital application to expand this sense of discovery and adventure to a portable device where the presence of a physical frame may not be within reach.

5.3 Digital Application Prototype

The digital application serves as an immersive, mobile extension to the physical frame. We considered a mobile application after evaluating the potential gaps in the physical frame experience in relation to our mission to make this experience as accessible as possible; Playscape users can use the application to connect and learn about their local biodiversity beyond the fixed frame position. We completed a competitive analysis to understand the gaps in the market and where our solution fit. We reviewed three competitors in the online nature exploration and education space: Pokemon Go, Seek by iNaturalist and Nat Geo Kids. By evaluating the strengths and weaknesses of these solutions, we determined that these experiences lack intention when highlighting or choosing locations to complete challenges. For example, Pokemon Go randomly uses map data to spawn Pokemon in sometimes dangerous areas while we aim to highlight and celebrate local green spaces. All of the competitors we viewed did not highlight each of the life stages of the species while we aim to have users empathize and 'grow' with the species. We also noted that Playscape has the potential to be more kid friendly, as most of these solutions lack bite sized information or are text heavy.

We envision that the digital experience is to be activated by visiting a Playscape physical frame. Upon visiting the frame, users will be able to download the digital application and load the species highlighted in the frame into the application. The goal of the application is to provide more context about their local habitats and biodiversity as well as opportunities for interactions for users, as prior research notes that outdoor education lets children learn in a contextualized way about their environment. Children initially learn about science concepts through their daily natural world interactions.

The design process for the prototype was iterative over the course of several weeks, in which we conducted concept and usability testing to gain insights. The application received valuable feedback from experts at the Lawrence Hall of Science, who had experience with working with children within our intended audience's age range of 7-13 years old. For the scope of the project, the digital application is an interactive Figma prototype with two distinct flows that highlights both animals that are representative of their local habitats but also species highlighted in any of the Playscape physical frames they visit.

The digital application has two flows. One flow is focused on children learning and accumulating knowledge about the species that make up their local biodiversity. The main focus of this flow is having children engage in gamified learning in order to learn more

about the animals populating their virtual ‘habitat’ and help them grow. This flow prominently features an animal life cycle quiz for each species (Figure 9) that asks basic, digestible questions that help users “grow” the animals and populate a fact sheet at the end (Figure 10). The fact sheet features facts such as the conservation status of the species and diet as well as a sightings map and videos of the species in their natural environment. After unlocking and completing the flow of your initial 3 species, the user can unlock more animals by either visiting another Playscape physical frame or discovering new species through the treasure hunt flow.

The other flow encourages users to connect with nature through intentional outdoor explorations. These outdoor explorations consist of searching for digital “treasures” located in local green spaces in the form of a treasure hunt feature (Figure 11). Additionally, there are additional incentives to go outside while learning more conservation status information: adding “rare” species that appear spontaneously in the app that can be found. The treasure hunts and associated treasures let the children see how their exploration of these spaces leads to a visible growth in their virtual habitat(s), such as the addition of certain trees or plants.

Due to testing constraints and the scope of the project, our team decided to test and delineate the digital experience from the installation experience; however, please refer to section 9 to further review the rationale and possible explorations in the future for better connecting the two parts of the Playscape system.

The screenshots and flows featured below in Figures 7-11 are reflective of what screens had been shown during usability testing. The final iterations will be referenced in the Figma file.

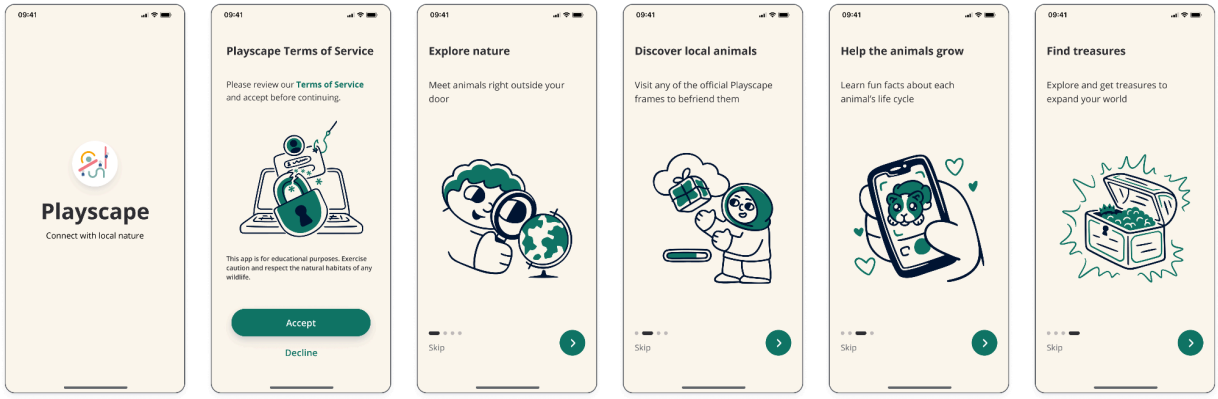


Figure 7. Onboarding flow of digital application.

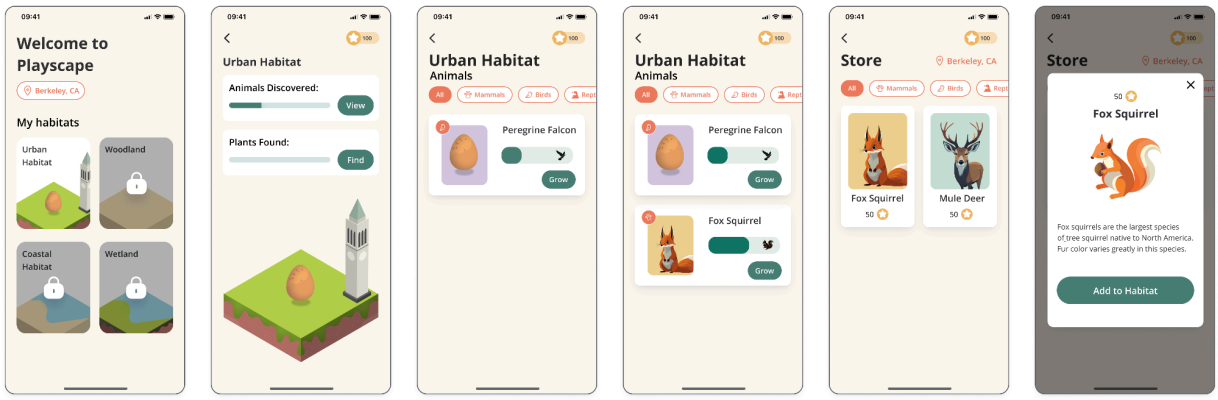


Figure 8. Homepage and Welcome Screen flow of digital application.

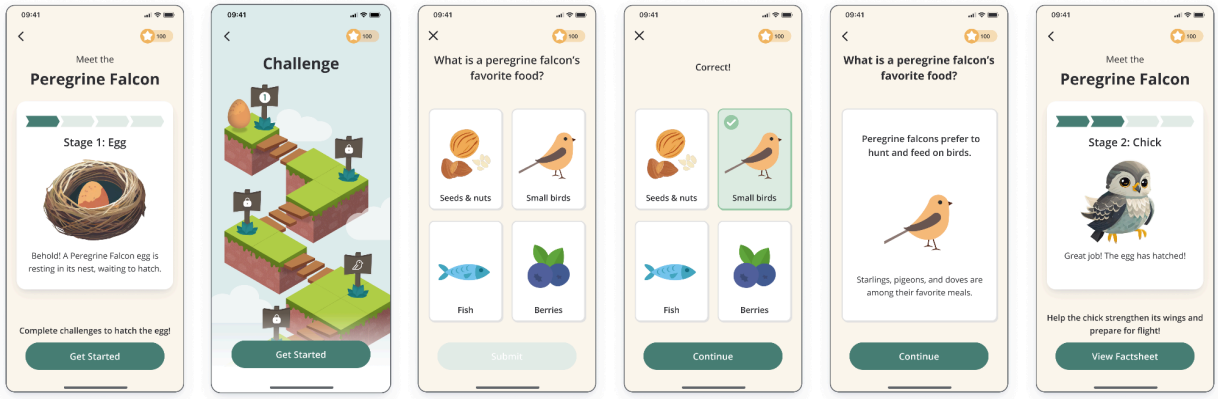


Figure 9. Animal Life Cycle Quiz flow of digital application.

Figure 10. Animal Life Cycle Fact Sheet flow of digital application.

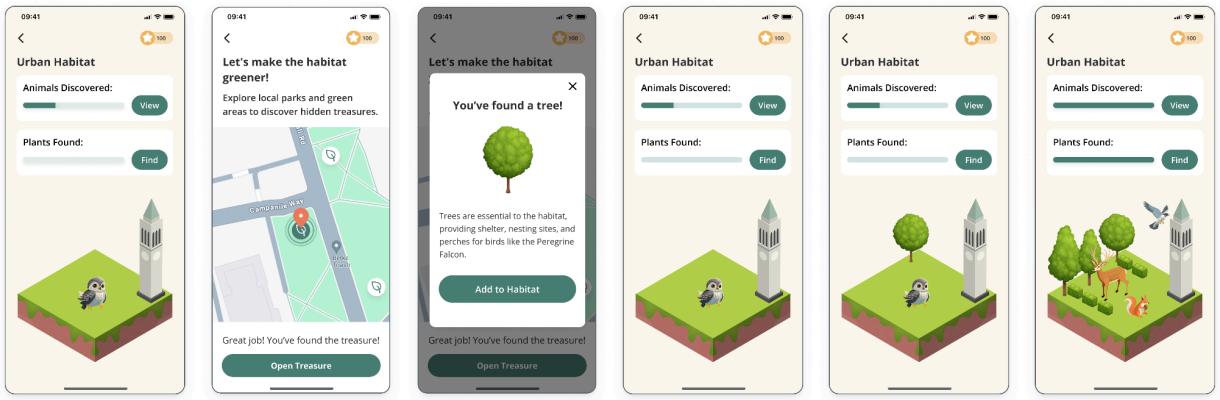


Figure 11. Treasure Hunt flow of digital application.

6. Testing

6.1 Overview

In order to better understand how users, including children, interacted with our installation and digital application prototypes, and to uncover prototypes' opportunities, strengths, challenges, and limitations, we conducted three tests. The first test was a 30-minute structured usability test and interview session taking place in front of South Hall at UC Berkeley's campus on the installation and digital application. The second test was a two hour observational study taking place at the Lawrence Hall of Science on the installation. The third test was a series of usability tests on the digital application.

6.2 Structured Play Session

We conducted one 30-minute session that included observation, structured interview questions, and usability testing with an 8-year-old child, where we tested both the installation and digital application. We recruited this participant through word of mouth and held the session in front of South Hall at UC Berkeley's campus. We positioned the installation such that some trees as well as the Campanile tower, a UC Berkeley landmark, were in frame. We started the session by introducing the installation and explaining any supplementary instructions. Then, we let the participant play at their own pace with the installation for 10 minutes, while we observed. At the end of the session, we asked the participant what they liked and disliked about the installation as well as a rating between 1 and 5 (where 1 meant they found it to be confusing to use and 5 meant they found it to be easy to use). After testing the installation, we introduced the digital application by handing over an iPhone with the prototype pulled up. Then, we let the participant interact with the digital application at their own pace for 10 minutes, while we observed their behavior. At

the end of the session, we asked the participant the same questions regarding their likes, dislikes, and overall rating. Our study protocol was approved by UC Berkeley's institutional review board (IRB).

6.3 Observational Study

We conducted a two hour observational study at the Lawrence Hall of Science to see how visitors would interact with the installation prototype. Visitors to the Lawrence Hall of Science are typically a combination of adults (parents) and children, ranging from birth to 18 years old, with the majority of children under the age of 13 years old. For the study, we set up the installation at the Lawrence Hall of Science's Outdoor Nature Lab for the first hour and at the outdoor terrace for the second hour. The Outdoor Nature Lab is an outdoor space with various kinds of flora and fauna where visitors can participate in activities, such as nature observation and scavenger hunts. This area was quieter than other parts of the center, whereas the outdoor terrace had much higher foot traffic. We included signage next to the installation informing visitors that they were being observed by UC Berkeley researchers. Once the installation was set up, our team spread ourselves throughout the area and took notes (without any identifying information) on who approached the installation (e.g. approximate age and gender), any comments they made about the installation, and if and how they interacted with the installation. Lastly, we added additional bigger instruction signage to the installation during the second half of the observation study. Our study protocol was approved by UC Berkeley's institutional review board (IRB).

6.4 Usability Testing

We conducted usability testing of our digital application with three staff members from the Lawrence Hall of Science to gather feedback and insights on the user experience. The testing aimed to evaluate the effectiveness and usability of the app in educating children (target age range: 7-13) about biodiversity through gamified interactions.

We utilized an interactive Figma prototype to facilitate the testing process. Participants were invited to navigate through various sections of the prototype while thinking out loud. We observed the participants as they interacted with the prototype and took notes of their actions, feedback, and any challenges they encountered. After they had completed the walkthrough, we conducted a semi-structured feedback session where participants were asked targeted questions about their overall impressions, the app's visual appeal, additional ideas they had, and their feedback on specific parts of the app, such as the homepage, animal life cycle experience, animal fact sheet screen, and treasure hunt experience.

7. Results

7.1 Installation

During our structured play session with an 8-year-old participant, we noticed that she spent the majority of the 10 minute play session drawing, specifically flowers, on the frame. While drawing, she accidentally activated one of the sensors with her elbow, and thus, she began to press each sensor to hear each animal's sound. When asked about her experience interacting with the frame, she noted that hearing the sounds of the animals was her favorite part of the installation. She also stated that there were no confusing parts about the installation.

During our observational study, we observed 59 visitors that approached or interacted with the installation. Of these visitors, 34 were children who looked to be below the age of 13 years old. The rest of the 25 visitors were adults, the majority of whom appeared to be parents, guardians, or relatives of the children who also approached or interacted with the installation. Five adults appeared to be independent visitors, and three adults were employees. Many of the adults who were accompanying visitors who were children played a facilitator or observer role, while their children interacted with the installation. 26 visitors managed to either press or attempt to press the audio sensors on the installation. Of these 26 visitors, 18 were children. 29 visitors drew on the frame, and of these 29 visitors, 24 were children. Three groups of visitors revisited the installation to interact with it once more. Overall, the installation appeared to be approachable given the number of visitors; however, upon approaching the installation, younger visitors, who appeared to be below 6 years old, seemed confused, became distracted, and left. Visitors spent varying amounts of time at the installation, ranging from less than a minute to 6 minutes, with the majority of visitors spending between 1-2 minutes at the installation.

There were a few technical challenges resulting from outdoor conditions that we uncovered from our studies. For instance, for both studies, the installation was stationed outside during daylight hours, and as a result, many participants seemed to not notice the green LEDs that lit up next to an animal upon its sensor activating. One of the LEDs was bright enough to stand out in the daylight, but the other two LEDs were not. Additionally, when we observed children and adults interacting with the installation in the outdoor terrace area of the Lawrence Hall of Science, an area with high foot traffic and a water fountain, we noticed that many participants could not properly hear the sounds coming from the frame. This was not as much of an issue at the other test sites.

There were additional challenges regarding the frame's height and sensors. Given the diversity in age among Lawrence Hall of Science visitors, some participants were quite young and, therefore, could not properly reach or see the sensors and parts of the frame due to their height. In a couple cases, either a parent had to lift their child up to better see

the frame and sensors or the child and parent left the installation. Additionally, one participant, after hearing the animal sounds, commented that one of them sounded like a bug, implying that the quality of the sounds, on top of playing in a noisy environment, was not high enough. Some participants also had trouble pressing on the sensors, as they had to use more of their body weight and force to press each sensor. While this may have been due to either a malfunctioning of the sensors or a lack of more sensitive FSRs, this could have also occurred due to our team's overestimation of younger users' body strength.

Of the 30 participants who drew on the frame, we observed that children drew not only on the front of the frame but also on the back of the frame, and many children who were near the frame with other children shared the frame space and moved around the frame to find empty spaces to draw. Children drew in a variety of ways, such as outlining the animal images, adding additional elements to the animals (e.g. bigger antlers on the deer), coloring in the missing parts of the animals, and drawing their own illustrations (e.g. flowers) in the empty space. One child even wrote out the phrase "He He Ha Ha" on the frame.

Though we noticed that more participants spent time drawing on the frame as part of their entire interaction with the installation, we did identify a few challenges. First, given that many children and adults visited and drew on the frame, the space on the frame began to fill up, causing our team to erase the frame in order to make room for more potential visitors. Additionally, children and adults had a hard time putting the markers back on the frame, as there was no designated area to put them in besides in the crevices of the frame. And lastly, one of the markers ran out of ink, causing a couple participants to feel frustrated and leave the installation.

7.2 Digital Application

During our structured session with the 8-year-old participant, we noticed that she spent approximately 6 minutes navigating through the entire digital application. The participant was able to understand and discern the intent of the app, making remarks such as the app allowed for "finding nature" and asked about "questions about nature". When asked about what they liked most about the app, the participant expressed that she liked how the app provided different "things to do" and also "places to go". When asked about any points of confusion, the participant remarked that the questions in the quiz were challenging.

During our semi-structured session with three staff members from the Lawrence Hall of Science, we received valuable feedback on our mobile application prototype. Overall, all participants expressed a positive impression of the app, describing it as engaging and well-suited for the target age range of 7-13 years old. Specifically, they appreciated the graphics, noting their appeal to younger children. Additionally, they observed that the information presented was appropriately scaled for older children. A participant noted that this interplay between visual style and content could potentially expand the app's appeal to a broader age demographic. More encouragingly, participants expressed interest in seeing

the full version of the app. The participants particularly appreciated the interactive elements, such as the flow and animations.

Feedback regarding the homepage highlighted the potential complexity of introducing different habitat types to younger children, but there was recognition of its educational value. Suggestions were made to link habitats in the app with real-world locations for added context, such as introducing a map view of California pinpointing nearby locations of different types of habitats. Additionally, a participant suggested incorporating interactive elements, proposing the ability to move species around the habitat within the app. As the participant noted, “Kids’ first reaction will be to move things around or scroll,” indicating the potential for increased engagement and interactivity.

During the session, participants provided insights into specific features such as the Animal Lifecycle (Quiz). They found the quiz flow smooth overall. They particularly appreciated the innovative approach of visualizing the animals’ growth stages, finding it both engaging and relatable. As one participant remarked, “The whole idea of leveling up is familiar for middle school kids.” However, there was uncertainty regarding the point system, with participants seeking clarification on how points were earned and their purpose. Nevertheless, participants responded positively upon learning about the store feature in the prototype, where points could be utilized to unlock new animals for further learning.

Regarding the Animal Fact Sheet feature, participants appreciated the inclusion of features such as a conservation status visualization, a sightings map, and the live photo/video gallery; however, valuable feedback was provided, suggesting improvements to enhance the user experience. Participants recommended including points of reference to depict the length and height of animals for better comprehension, such as relation to other species or humans. Additionally, suggestions were made to incorporate more icons and illustrations to enhance user-friendliness. Another suggestion involved providing more descriptive text or context for photos in the photo gallery. Furthermore, a participant emphasized the importance of a better correlation between text and images, particularly in the habitat and threats section, to improve clarity and understanding.

Regarding the Treasure Hunt feature, participants expressed that the concept of finding digital treasures in local green spaces did not fully translate. It was not explicit that the intent of the feature was to prompt children to visit local green spaces, rather than any outdoor spaces. To enhance relevance and engagement, suggestions were made to relate digital treasures to real-world biodiversity hotspots. For example, correlating the number of digital treasures found with the biodiversity level of an area could incentivize exploration of more biodiverse regions. Additionally, participants recommended extending the treasure hunt to include real-life objects, such as identifying and locating trees in the physical environment. To maintain user engagement over time, participants proposed introducing rare species that could only be unlocked for a limited timeframe, thereby creating a sense of urgency and excitement.

In summary, the feedback from the three staff members from the Lawrence Hall of Science underscores the importance of ensuring that information presented in the app is accessible, relatable, and easy to comprehend for the target audience of children aged 7-13. Additionally, it highlights the opportunity to strengthen the app's connection to the real world so as to align with our objective to promote engagement with local green spaces and biodiversity hotspots. To achieve this, we saw opportunities to explore innovative ways to enhance the treasure hunt experience. Lastly, improvements to the clarity of the point system and store feature would also be essential for enhancing user engagement and overall usability of the app.

8. Final Digital Application Design

These changes reflect the learnings from the results from section 7. We considered alternative information layouts for the Factsheet feature and curated images (instead of illustrations) of local species in their habitats. With regards to work we would have liked to pursue for the digital application, based on our findings from usability testing, there are a few areas for iteration and continued effort. We explored different rewards, or digital "treasures," to incentivize and engage children to partake in learning challenges. Within the Treasure Hunt feature, we investigated how to incorporate conservation status, an important information marker for species. We would also explore the possibility of adding potential sustainable behaviors and actions to take throughout the experience, especially when users are near biodiversity hotspots.

The Figma prototype can be accessed here.

9. Findings

Interactive features can drive user engagement

Overall, we learned that having multiple interactive features can be a driver for engagement, especially when geared towards the right age group. In our installation, we had two primary features–pressing the habitat element sensors to activate the animal sounds and drawing on the frame, particularly on and around the animal images. Majority of participants immediately began engaging with the installation through either of these two features or a combination of both features. In addition, making space for collaboration can contribute to a more dynamic experience, as many visitors, both adults and children, were interacting with multiple parts of the installation. Lastly, having large, visible signage with directions can help strengthen interactivity. For example, some younger participants, especially those who were significantly shorter than the installation's target height, seemed confused because the existing signage was placed too high for them.

Accessibility and relatability of information is at the forefront of children's experiences

While we built the installation and digital application with a target audience of children ages 7-13 years old, users' abilities within this age range still varied. This variance applies to characteristics such as height, strength, reading level, comfort level with digital applications, and familiarity with biodiversity and scientific content. As such, designing with these characteristics in mind can help improve children's overall experience during playful learning. We also learned through usability testing with nature center experts that while our visuals and included information aligned with the target audience, there was room for future iterations when considering details such as being less text heavy, chunking the information into bite-sized pieces, and considering what is considered technical jargon (i.e. conservation status). For example, the animal factsheet screen in the prototype received feedback to include more description text or captions as well as adding more imagery to illustrate the facts.

Environmental factors impact the design of TUIs

Environmental factors can have a significant impact on the performance of outdoor tangible user interfaces. These factors include time of day, amount of daylight, noise, and weather conditions. For example, while we were building the installation, the acetate screen easily trapped condensation based on the weather of that day due to a gap between the screen and the frame, which affected the transparency of the screen and the animal images' overall visibility. As a result, our team had to seek out other methods to adhere the acetate screen to the frame.

Interaction maintenance is central to design longevity

In order to accommodate multiple users, we learned that ensuring there are mechanisms in place to reset and maintain the entire experience for each user. In our installation, we ensured that both sides of the frame could be adequate drawing surfaces and included markers that had erasers on top; however, during our observations, we noted that space for drawing would run out despite having two areas and that most people did not erase their creations. A few participants erased some creations to make room for their own drawings, but this was not the case for all participants.

10. Future Work

Throughout this project, we have explored the ways in which both screen-less and screen-based technologies can be used to promote outdoor play while deepening children's connection with nature. While our prototypes and research studies have provided valuable insights around designing outdoor play experiences, there are several areas for further development and exploration. In this section, we highlight the changes we would want to incorporate based on our findings and outline the potential directions for future work.

In terms of the work we would have liked to pursue for the installation, first, our team would collect additional qualitative feedback beyond observations in order to better understand some of the challenges and opportunities arising from interacting with the installation and digital application. In addition to collecting more data, we also would address the design and technical challenges that arose from interacting with the installation. This includes exploring other ways to indicate each animal's sound beyond LEDs, incorporating an adjustable height mechanism to accommodate height variations, integrating more visible signage with simpler instructions, diversifying the sensors to accommodate diverse physical abilities (e.g. photocells, capacitive sensors, potentiometers, voice activation mics), increasing the volume of the animal sounds, and adding proper storage for the installation's markers. We would also consider other possible information about each animal to embed and explore whether there are other forms of sensory play to showcase this information. Lastly, we would consider the possibility of including not only animals but also other types of species (e.g. flora, fauna, insects).

As we briefly mentioned in Section 5, our intention for the Playscape system is such that both the installation and digital application can be used in tandem with each other. While we were unable to fully actualize this joint experience, there are a few ways in which we envision this aspect of the system to be designed. First, we would incorporate a QR code onto the installation's frame, allowing any user who approaches and interacts with the installation to download the digital application. Upon download completion, users are then able to add the species featured on the installation to their digital collection on the app. Another way in which we envision the system is through scaling the number of installations and strategically placing these installations in biodiversity hotspots, such that users are motivated to visit these hotspots and unlock additional species.

Lastly, we considered ways to develop the Playscape system with more sophisticated interactions, both physical and digital, that could enhance user interactions. Currently, the installation is a static prototype and features a clear screen that invites users to look through and observe their surroundings; however, examining how a mobile or static version of the installation and the role of a transparent screen could enhance the observation experience is crucial. For instance, the screen could capture the actions and behaviors of local species to aid the observation experience. Additionally, a more mobile or portable version of the installation could engage a wider audience by allowing the experience to be easily transported to multiple locations and educational contexts. The static version of the installation could offer more opportunities for strategic placement, as previously mentioned, and integration with surrounding infrastructure or environments. We also received feedback about other current exhibits (i.e. the Oakland Zoo) that highlight roles that users could embody or feel empowered by. We could introduce a narrative that helps guide children through our experience and create a contextual framework for their play; for example, we could allow for roles such as being a biologist or conservationist and give them "missions" to assist with. Lastly, incorporating augmented reality features into the digital application to highlight the frame element from the installation could further

enrich users' experiences with observing, learning from, and, ultimately, connecting with nature.

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Lastly, we would like to thank the I School Community for all of their support in allowing us to build and test our installation in front of South Hall.

Appendix

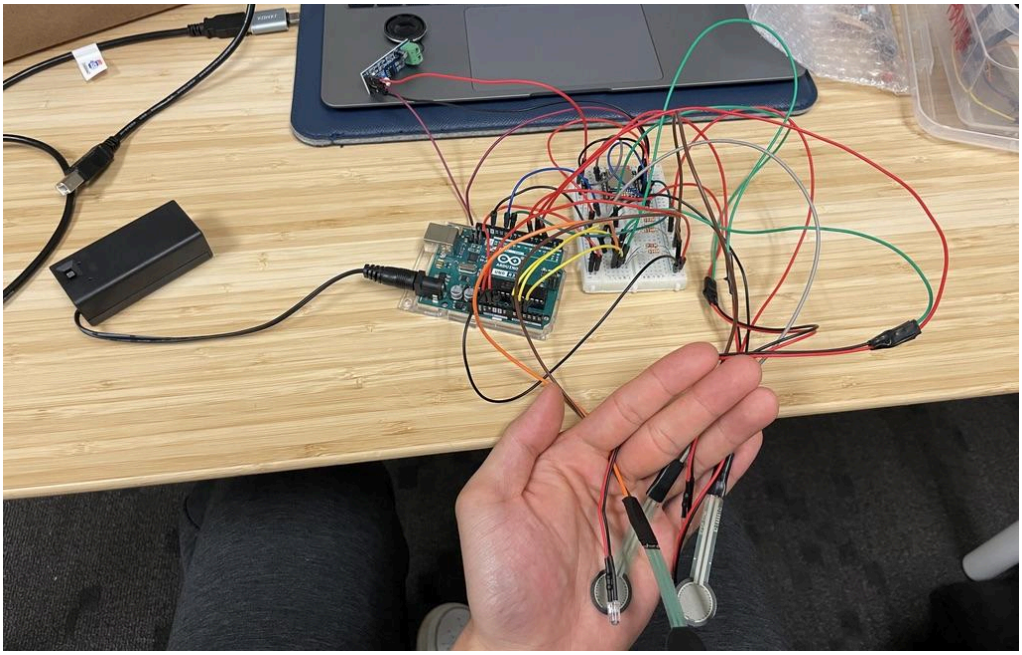
Technical Implementation

```
#include "SoftwareSerial.h"
#include "DFRobotDFPlayerMini.h"

// Initialize software serial on pins 10 and 11
SoftwareSerial mySoftwareSerial(10, 11);  // RX, TX
DFRobotDFPlayerMini myDFPlayer;
String line;
char command;
int pause = 0;
int repeat = 0;
const int FSR1 = A2;
const int FSR2 = A1;
const int FSR3 = A0;
const int LED1 = 3;
const int LED2 = 5;
const int LED3 = 6;

void setup() {
 // Serial communication with the module
 mySoftwareSerial.begin(9600);
 // Initialize Arduino serial
```

```
 Serial.begin(115200);

 // LEDs
 pinMode(LED1, OUTPUT);
 pinMode(LED2, OUTPUT);
 pinMode(LED3, OUTPUT);

 // Check if the module is responding and if the SD card is found
 Serial.println();
 Serial.println(F("DFRobot DFPlayer Mini"));
 Serial.println(F("Initializing DFPlayer module ... Wait!"));

 if (!myDFPlayer.begin(mySoftwareSerial)) {
   Serial.println(F("Not initialized:"));
   Serial.println(F("1. Check the DFPlayer Mini connections"));
   Serial.println(F("2. Insert an SD card"));
   while (true);
 }
 Serial.println();
 Serial.println(F("DFPlayer Mini module initialized!"));

 // Set DFPlayer volume to max (0-30)
 myDFPlayer.volume(30);
}

void loop() {
 int sensorValue1 = analogRead(FSR1);
 int sensorValue2 = analogRead(FSR2);
 int sensorValue3 = analogRead(FSR3);
 // Serial.println(sensorValue1);
 // Serial.println(sensorValue2);
 Serial.println(sensorValue3);
  // Play falcon (range is 0- ~760 so 100 is a small threshold to overcome)
 if (sensorValue1 > 100) {
   char play = '1' - 48;
   Serial.println("Playing falcon sound.");
   myDFPlayer.play(play);
   digitalWrite(LED1, HIGH);
   delay(4000);
   digitalWrite(LED1, LOW);
   delay(300);
 }

 // Play squirrel (range is 0- ~760 so 100 is a small threshold to overcome)
 if (sensorValue2 > 100) {
```

```
  char play = '3' - 48;
  Serial.println("Playing squirrel sound.");
  myDFPlayer.play(play);
  digitalWrite(LED2, HIGH);
  delay(4000);
  digitalWrite(LED2, LOW);
  delay(300);
 }

 // Play deer (range is 0- ~760 so 100 is a small threshold to overcome)
 if (sensorValue3 > 100) {
  char play = '5' - 48;
  Serial.println("Playing deer sound.");
  myDFPlayer.play(play);
  digitalWrite(LED3, HIGH);
  delay(3000);
  digitalWrite(LED3, LOW);
  delay(300);
 }
  delay(2);
}
```

Appendix 1: The Arduino sketch that was loaded onto the Arduino Uno microcontroller.



Appendix 2: Completed circuit of FSRs, Arduino Uno, 9V Battery, Breadboard, DFPlayer Mini, LM386 Amplifier, and Speaker.

Parent Interview Guide

Introduction

My name is [Researcher's name], and I am a researcher from UC Berkeley, where we are working on a project related to children and outdoor time. My primary role as a researcher is to gather information about people in order to better understand their views, perspectives, and needs.

Today's session will be about 45 minutes. Your participation is optional, so, if at any point you need or want to stop, please let me know.

I am not looking for any particular answers, but merely your honest opinion and feedback. Our session today will be recorded for transcription purposes, as previously stated over email; however, this conversation is also confidential, so we will delete the recording as soon as transcription has been completed.

With that out of the way, let's get started.

Warm up + Background

- Tell me a bit about yourself and your children.
    - Which city do you live in?
- What grade is your child (children) in?
- Do they have any specific interests or hobbies? If so, what are they?

Daily Routines + Current Outdoor Activities

- What does a typical day look like for your child?
    - What are some indoor activities that your child enjoys?
- Approximately, how much time does your child spend outside on a daily basis? Weekly?
- Do they like spending time outside?
    - If no:
        - Why not?
        - Are there specific aspects of the outdoors that they do like?
- Can you share some of your child's favorite outdoor activities and why they enjoy them?
- Who do they typically spend outdoor time with? Friends? Family? Class? Other?

    - Does your child's social network affect whether or not they spend time outside? How do you know?
- Which outdoor environments do they frequent? (e.g. parks, neighborhood, etc.)
- Are there any challenges or barriers that prevent your child from spending more time outdoors?
    - Does location have an impact? School? Safety?
        - [prodding ideas: e.g. how far of a distance (estimated, any metric) would you be comfortable letting your child explore away from you physically?]
        - Transportation access to go between places of interest? (take bus, scooter, walk, etc.)

Parental Influence

- What is your typical daily routine like?
- To what extent do you participate in your child's outdoor play?
    - If it's a lot:
        - What do you enjoy most about participating?
        - What do you enjoy least about participating?
    - If it's not a lot: (note: if they don't participate a lot: would they even WANT to?)
        - What hinders your participation?
        - What do you enjoy most about participating?
        - What do you enjoy least about participating?
- Do you find yourself encouraging your child to engage in outdoor activities?
    - If yes:
        - How do you do this?
    - If no:
        - Can you tell me more about your answer?

Technological Influence + Other Influences

- Can you tell me about your child's screen time habits?
    - What kinds of devices does your child use?
    - Can you share your perspective on the role of technology and devices in your child's life?
- How does screen time affect the amount of time your child spends outside?

Solutions + Suggestions

- How does the school environment encourage or discourage outdoor time? What about during school breaks?
- Are there community resources or initiatives that you're aware of that support and promote outdoor play, education, or just being outside for children?
    - Are you aware of any outdoor spaces in a specific local environment/area that you feel your child would benefit from visiting?
- We talked about outdoor activities earlier in the conversation that your child partakes in. What are some general games and activities that your child likes to play? *(Note: these activities don't have to take place outdoors, they can also include technology, etc.)*
    - What are some common aspects of these activities, games, and forms of play that you think your child enjoys?
        - Has your child taken part in activities such as scavenger hunts?
- Lastly, in a perfect world, what would be your ideal solution for encouraging more outdoor time for children?

Conclusion

- Given everything we've discussed thus far, what is the most important thing to you when it comes to encouraging outdoor time for your children?
- Are there any additional insights or experiences you would like to share regarding our conversation?

Thank you so much for taking the time to participate in our research study!

Structured Play Session Script

Introduction (3 minutes)

Hello. We are researchers at UC Berkeley. We have a new installation here that combines technology and education on nature. Here is the installation *(touching the installation and features)*. As you can see, there are some instructions that allow you to learn more about the environment.

Any questions so far? *(Answer any questions.)*

Play Session (up to 10 minutes)

Now that you've had a little introduction, I am going to ask you to play at your own pace. If you have any questions, just let me know."

You can stop this play at any time. I will be right over here.

If it's OK with you, I would like to ask your parent to wait over there by the benches, so that you can focus on the installation. *(Politely ask the parent to leave the room.)*

End of Play Session (5 minutes)

How was the installation? What did you like about it? What did you not like about it? What would you want to add or see more of?

On a scale of 1 to 5, where 1 = very difficult and 5 = very easy, how would you rate your experience using the installation?

Digital Prototype Testing (up to 10 minutes)

Now, we will move on to the next part of the session, where we would like to learn how you use a digital app that we have created. Here is a phone for you to use. Feel free to explore the app.

We would like you to talk out loud and share your thoughts as you use the app. What do you see? What is standing out to you? What is confusing? What do you like? Did you learn anything new?

End of Digital Prototype Testing (up to 5 minutes)

How was the app? What did you like about it? What did you not like about it? What would you want to see more of? What would you want to add?

On a scale of 1 to 5, where 1 = very difficult and 5 = very easy, how would you rate your experience using the app?

Literature Review

Summary

In this paper we explore existing research on the problem of children spending less time playing outdoors, and the benefits of outdoor play. To help educate us on our solution, we also explore previous research on different types of play as well as the form our solution could take, looking at physical and digital components.

Decrease in Outdoor Play

Today there is a problem where children and teens are not playing outside as much as they once did, and those with a low socioeconomic status are especially disadvantaged. Over the last decade, play has become less valued in the school systems as they have put more emphasis on academic curriculum (Neuman & Freschi, 2023). In a wide context, a survey indicates that American children now spend 35% less time engaging in unstructured outdoor play than their parents did (Robinson, 2020). According to the survey, 65% of parents reported daily outdoor play during their childhood, whereas only 30% of their children do the same today (Robinson, 2020). Furthermore, the survey reveals a concerning trend, with almost one in five children today playing outside only once a week or less.

There are many known contributing factors to this decline. These include cultural and societal causes such as the loss of our public spaces through reduced investment, social segregation of urban spaces, and increasing focus on individual productivity. Some other barriers particular to reduced outdoor play among children include perceptions of neighborhood safety and concerns about increased traffic.

Benefits of Outdoor Play

The fact that children are not playing outside much is a problem because outdoor play brings many benefits including healthy brain development relating to socio-emotional and cognitive benefits, physical health, mental health, and improvement to children's outcomes. First, outdoor play is important for healthy child brain development (Milteer et al, 2012; Loebach et al., 2021; Christian, 2022; Shaffer, 2018). Active play is central to child development as it allows children to develop creativity, imagination, cognitive strengths, and emotional strengths (Milteer et al, 2012; Christian, 2022; Neuman & Freschi, 2023). Outdoor play also supports healthy brain development by encouraging exploration which can help children strengthen wayfinding and decision making skills, and the ability to respond to changing contexts (Loebach et al., 2021). According to a qualitative study designed to explore how a parent plays a key role in their child's level of outdoor play, its findings suggested that parents are unaware of the potential benefits that outdoor play has to offer, especially the associated socio-emotional and cognitive benefits (Robinson, 2020). While each of the participants in the study associated the benefits of outdoor play with mainly physical benefits, only 1 out of 5 participants considered the social benefit of outdoor play, stating that it is a good way to learn how to interact with others (Robinson, 2020).

Outdoor play is also important for physical health by increasing physical activity levels (Milteer et al., 2012; Loebach et al., 2021; Christian, 2022; Shaffer, 2018). Specifically, research has found that 3-12 year old children who spend more time outdoors accumulate more physical activity and spend less time being sedentary, and for 7-to-14-year-olds, each hour spent outdoors daily was associated with an additional seven minutes of moderate-to-vigorous physical activity and a 13-min decrease being sedentary (Loebach et al., 2021). Children who engage in physical activity put them at reduced risk for chronic diseases like obesity and type 2 diabetes (Christian, 2022).

Engaging in outdoor play also improves children's mental health (Christian, 2022). Children and teens have reported skyrocketing levels of anxiety and depression in recent years, along with their being a decrease in play which may be one reason that is contributing to anxiety and depression (North, 2023).

Forms of Play

To inform our solution, we looked at different types of play experiences. Play shouldn't be looked at as a single type of activity; it comes in many different forms (Shaffer, 2018). First, we examined free play, or unstructured play, versus guided play, or structured play. Free play is when children have independence and decide how they want to play. Guided play is when there is a focus on a specific learning goal (Zosh et al., 2022). An example of this would be probing questions or a structured game. Free play and guided play are both important for children to partake in, but there are a few differences. Free play's benefits emphasize allowing children to explore, imagine, express themselves, problem solve, and develop social skills (Zosh et al., 2022; Moyer, 2016; Bitoy, 2021). Guided play's benefits emphasize the ability to introduce new ideas the children would not otherwise explore, and teach them new concepts (Bitoy, 2021). Research has found that children learned more vocabulary and spatial skills through guided play as opposed to free play (Zosh et al., 2022). Nevertheless, free play and guided play are both essential for children's development.

Scavenger hunts and sensory play are a specific type of play that children enjoy due to their exploratory nature. Scavenger hunts provide both a structured and unstructured play experience where children can learn new things, but also get to explore and be creative. Consistent with the general benefits of play, scavenger hunts also develop creative problem solving skills, improves observational skills, and enhances sensory development (LaChance, 2016). Outdoor scavenger hunts are a form of sensory play in that they can involve sight, smell, taste, touch, and sound (Kable, n.d.). In addition to having the general benefits of play, sensory play is also important for child development because it helps stimulate the brain by building nerve connections, and they can learn about the world (Kable, unknown; Palumbo, 2023).

Another type of play we investigated was playful learning. Playful learning includes both free play and guided play where someone is teaching children concepts while providing them access to specific materials, guidance, and hands-on engagement (Neuman & Freschi, 2023). Children learn best when they are doing, and playful learning allows children to reap the benefits of play including exploring, practicing social and emotional skills, problem solving, and communication (Neuman & Freschi, 2023). Playful learning allows children to demonstrate their knowledge that cannot be captured through worksheets or assessments (Neuman & Freschi, 2023). An example of playful learning is the program Play Labs which used play-based learning for kids aged 3-5 where they were provided with culturally relevant stories and dances with a space for the children to explore. Research found that Play Labs improved childrens' development in physical, cognitive, and social domains (Neuman & Freschi, 2023).

Physical Installations

There is little research on outdoor installations but we looked into the Little Free Library which is a very successful outdoor installation. The installment of the 50,000th Little Free Library (LFL) at the Illumination Foundation in Santa Ana, California, exemplifies the profound impact of these mini libraries in providing access to communities (Aldrich, 2016). This milestone, estimated to share 36.5 million books annually and fostering connections among 600,000 neighbors. Todd Bol, the creator and founder of the Little Free Library, says they are "more than cute boxes of books… we've established a global network of stewards, built partnerships with publishers and literacy organizations, and developed programming that leverages the power of sharing books to bring communities together" (Aldrich, 2016). A Huffpost article on why one should check out LFLs says that they foster communities globally across all 50 states and to seven other countries (Aldrich, 2017). The creators provide support and guidance on installing one and the reviewers have noted LFLs promote low-tech solutions for community engagement and high-tech digital connectivity. From this, we know that physical installations can be successful as many people enjoy LFLs.

Incorporating Digital Technology

In a research study on general app-based solutions for kids, McGlynn-Stewart, Maguire, and Mogyorodi showcased that open-ended tablet applications for outdoor play and learning encouraged active engagement and enhanced children's connections to nature. Educators, initially cautious about technology hindering outdoor play, observed that tablets, when integrated purposefully, supported collaborative learning, creativity, and literacy skills (McGlynn-Stewart, Maguire, Mogyorodi, 2020). The findings emphasized that such app-based solutions can enrich a child's sense of exploration of the environment and foster deeper connections to nature.

We also examined the phenomena of Pokémon GO and how it got a lot of attention for being an app that got a surprising number of people outside. Fiona Wong's research

analyzes the detrimental effects of a sedentary lifestyle, linking it to various health risks highlighted by the World Health Organization. The research reveals that sedentary individuals experienced significant improvements in physical activity through playing Pokémon GO, particularly in increased outdoor time and walking/jogging, with players dedicating nearly 98.43 minutes per week to intentional physical activity while playing. Specifically, previous sedentary players showed a remarkable increase in walking/jogging time, approximately 108.19 minutes per week, surpassing the average time of the entire player group. These findings correspond to other studies, demonstrating that Pokémon Go players exhibited elevated daily steps by 1473, indicating a 25% boost in physical activity compared to their pre-gaming activity levels (Wong, 2017).

Why did Pokémon GO work? A study on its impact on college students analyzed motivations behind playing the game. Results identified three player groups with distinct motivations — Pokémon enthusiasts, individuals seeking physical activity, and those curious and social. The findings emphasized that the perceived and objective benefits of Pokémon GO hinge on individual motivations (Marquet et al., 2017). It is important to note that the number of people actively playing peaked upon debut and dropped within a month of the game's release (Chong et al., 2018); however, an analysis shows that there are currently over 84 million active players as of November 2023, over seven years after the release. From looking at past research and Pokémon GO, we see how digital technology can encourage children to go outside.

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