Understanding and redesigning digital media resources for family environmental learning

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Project abstract

This project addresses fundamental questions about how families learn about the environment and, based on that, how we might better design digital media that supports environmental learning. Climate change is notoriously difficult to visualize; it is characterized by uncertainty and processes that cannot be directly observed, often making it feel intangible and abstract. Yet, visuals and technologies are powerful in their ability not only to convey importance and urgency, but also to motivate action and engagement. Recent years have seen a new wave of different technologies -- from documentary movies to interactive data visualizations -- that make science learning more accessible than ever, but little research exists to examine the affordances and limitations of such resources. By understanding why, how, when, and where parents and youth engage with digital media resources for environmental learning, we can help journalists, artists, educators, and scientists design and create experiences that sustain interest in, and motivate action for, our world. Crucially, this research study can inform how best to engage diverse audiences, including children and families, across various technology-enhanced platforms. It is unique in its interdisciplinary nature -- building on research from the learning sciences, psychology, child development, and environmental communication -- and its novel methodology of using remote diary studies to capture data over an extended period of time from diverse family participants across the country.

Background

Research shows that a significant amount of learning occurs beyond classroom walls, in homes, museums, gardens, after-school programs, and increasingly, online (Falk & Dierking, 2010; Banks et al., 2007; Osborne & Dillon, 2007). Technology plays a growing role in supporting student learning, changing not only how young people participate in our society and culture, but the very nature of knowledge production (Ito et al., 2008; Hsi, 2007). For science and environmental learning in particular, children's thinking is shaped and supported by digital media (Bell et al., 2009) and "trusted messengers" like parents, teachers, and peers (Crowley et al., 2001; Corner et al., 2015; Eagles & Demare, 1999). Furthermore, parents play a key role in sustaining children's interests in the long term and facilitating opportunities for joint-media engagement, which is

critical to child development and learning (Livingstone & Blum-Ross, 2019; Barr, 2019). Research studies also demonstrate that the effects of child-focused, environment-related interventions can transcend generational boundaries in multiple directions; children can influence the attitudes and behaviors of their caretakers too (Boudet et al., 2016; Damerell et al., 2013). In this project, I build on research from the learning sciences, psychology, child development, and environmental communication to investigate how families learn about the environment and, in particular, how they engage with digital media resources in their everyday lives.

As climate change becomes an increasingly politicized topic, many schools have turned away from teaching about it (Braus, 2020). A 2019 survey of parents and teachers in the U.S. found that despite overwhelming support (80% for parents and 86% for teachers) for teaching climate change in schools, less than half of parents and teachers actually talk and teach about climate change (Kamenetz, 2019). The lack of environmental education in schools is especially concerning in the context of three key trends:

1) The rapid changes of our environment, as evidenced by record temperatures, ocean acidification, sea level rise, and more (NASA, 2020), which create an urgent need for attention and innovation in sustainability.
2) The concurrent decline in civic and moral education, which are closely tied to environmental education -- our democracy, in addition to our planet, is at great risk if we cannot help our youth gain the knowledge, skills, motivations, values, and commitment to make and act upon informed decisions about our environment (Braus, 2020; Orr, 2019).
3) The disparate impact of climate change (e.g. extreme weather-related events and food insecurity) on underrepresented and underserved populations, who may not have access to the science centers and organizations that engage youth in environmental learning (United Nations, 2016).

This is a critical time to understand how diverse parents and children engage in environmental learning. Using a mixed-methods approach including remote diary studies and in-person focus groups, I collected and analyzed a rich set of quantitative and qualitative data about family environmental learning with the ultimate goal of providing a series of recommendations for journalists, artists, and educators who create environmental learning experiences for children and families. While past research has separately explored family learning with digital media (e.g. Ito et al., 2008; Hsi, 2007; Livingstone & Blum-Ross, 2019), the impact and design of climate imagery (e.g. Ballantyne et al., 2016; Chapman et al., 2016; O'Neill, 2017; Wang et al., 2017), and environmental learning in the family context (e.g. Crowley et al., 2001; Corner et al., 2015; Eagles & Demare, 1999), high priority questions at the intersection of all three remain unanswered. This research documents and theorizes how best to support environmental learning for youth and

families with a particular focus on digital learning technologies. Additionally, it will help lay the foundation for advances in remote data collection approaches, tools for multifaceted data analysis, and innovation in climate change storytelling -- all of which contribute to the broader efforts of using education, communication, and technology to mitigate the imbalance between human society and the natural world.

Methods

There is no place like home… to understand how families learn together. To get a fuller picture of environmental learning moments, I needed to be a fly on the wall — a difficult research task on its own, but made nearly impossible by the ongoing COVID-19 pandemic that disrupted almost every aspect of daily life. Instead of conducting in-person research, I leaned on remote tools to connect with families across the United States. This study utilized dscout (dscout.com), a smartphone- based, remote research platform that allows researchers to reach and manage diverse participants. Using a free mobile app, participants can view and complete a range of research tasks, such as submitting a video-recorded response to an open-ended question or answering typical survey-style questions. In addition to documenting moments and processes in real-time, participants can easily share memories, preferences, motivators, and suggestions.

Data were collected on dscout from February to March 2021, and occurred in two phases: the first was a remote diary study spanning two weeks, where participants reported on several environmental learning moments; the second included remote semi-structured interviews with a subset of the diary study participants. While the diary study enabled access to participants in their own authentic environments in real-time, interviews allowed for deeper investigation, understanding, and insights into the participants, their lives, and their worldviews. Both methods were crucial for answering the research questions at hand, and different methodological approaches for analysis reveal unique but complementary findings to understand environmental learning in the home context.

Participants

To recruit participants for this study, I administered a screener questionnaire through dscout, which hosts a database of over 100,000 participants nationwide. The screener, completed by the adult caregiver (generally a parent), included demographic questions (e.g. ethnicity, income, geographic location), a series of questions to assess views on climate change (Chryst et al., 2018), an open-ended response about a memorable weather event their child experienced, and a video-response question about a recent environmental learning experience with their child. The latter two questions were designed to evaluate quality and diversity of responses.

A total of 549 people from dscout's participant panel expressed interest in the study by completing the initial screener questionnaire, which included IRB consent to participate in research; of those, 112 respondents fit our study criteria: (a) having at least one child in the 3rd - 8th grade, and (b) the applicant had given consent for their responses to be used for research. The priority for sampling was to achieve a distribution of the Six Americas segments that as closely as possible resembled that of American adults in December 2020 (26% alarmed, 29% concerned, 19% cautious, 6% disengaged, 12% doubtful, and 8% dismissive; Leiserowitz et al., 2021); because the dscout sample fell more towards the alarmed / concerned end of the scale, all applicants from the latter three segments were selected first. Within the remaining three segments, applicants were sorted into three household income groups ($0-49K, $50-124K, $125K+) and randomly selected within those groups. Of the 112 complete screener responses, 66 were invited to participate; 3 did not accept the invitation within two days, and 5 participants were unable to complete the full diary study due to medical issues or other emergencies. In total, 58 participants from 25 states successfully completed the diary study. Most (81%) were female and 64% self-identified as white, 16% as Black, 12% as Latinx, and 7% as Asian. In line with dscout recommendations, participants were offered a $65 thank you gift for their participation in the diary study.

Following the diary study, I invited 13 of the participants for the semi-structured interviews. Based on the diary study entries, I applied tags to each caregiver to categorize their views on learning and climate change as well as the types of environmental learning experiences they engaged in with their child. Interviewees were recruited to cover the range of tags, and also to roughly mirror the proportions for the diary study participants for gender, age, income, ethnicity, political preferences, and the Six Americas segmentation (i.e. SASSY). All 13 caregivers completed the interview and received an additional $75 as a token of appreciation for their participation.

Figure 1 below shows the geographic distribution of participants for the diary study (red markers) and the interviews (blue circles). Characteristics of both samples are summarized in Table 1 below.

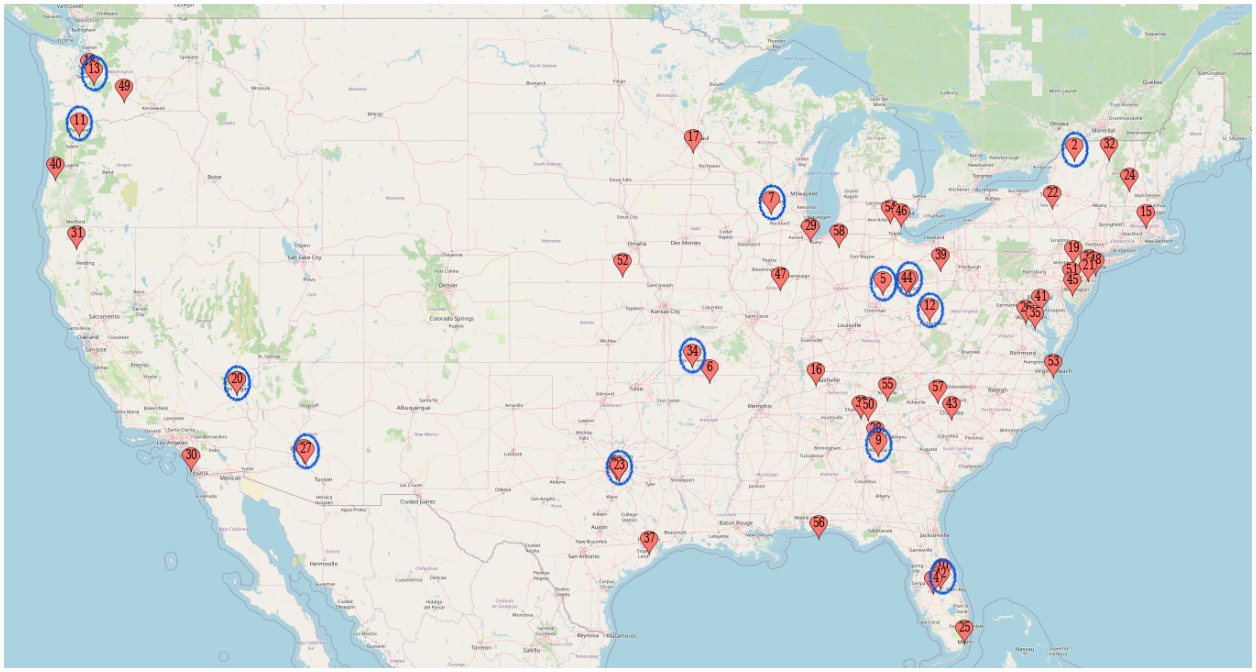

Figure 1. Red markers indicate diary study participants, blue circles indicate interviewees.

Table 1. Characteristics of the study participants.

	Diary study (n = 58)	Interview (n = 13)
Gender		
Female	47	11
Male	11	2
Age		
under 24	1	0
25-29	3	1
30-34	6	0
35-39	13	2
40-44	19	7
45-49	12	3
over 50	4	0
Ethnicity		
White	37	7
Black or African American	9	2
Hispanic or Latino	7	2
Asian	4	1
Prefer not to say	1	1
Gender of focal child		
Female	32	6
Male	26	7

Grade of focal child		
3rd grade	14	2
4th grade	12	5
5th grade	7	1
6th grade	7	2
7th grade	10	3
8th grade	8	0
Income		
$25,000 to $49,999	10	1
$50,000 to $74,999	6	3
$75,000 to $99,999	8	2
$100,000 to $124,999	8	2
$125,000 to $149,999	10	2
Over $150,000	16	3
Political preferences		
Democrat	22	5
Republican	16	2
Independent	16	4
Other	3	2
Cause of CC		
Human	37	10
Non-human	9	2
Both	12	1
SASSY category		
Alarmed	20	5
Concerned	25	5
Cautious	7	1
Disengaged	1	1
Doubtful	2	0
Dismissive	3	1

Materials

For this research study, all data was collected through the dscout platform. Because the participants were recruited from the dscout participant database, most of them were familiar with the format of dscout studies and interfaces for the mobile application (see Figure 2 for a screenshot of the participant view of the diary study, which displays one question per screen). By design, dscout only supports participant engagement through the dscout smartphone app; it makes it easier to record and upload media responses, and also allows participants to view and complete tasks and questions while on the go. The interviews were also conducted through

dscout using their “Live” feature (see Figure 3 for a screenshot of the researcher view of the Live interview platform).

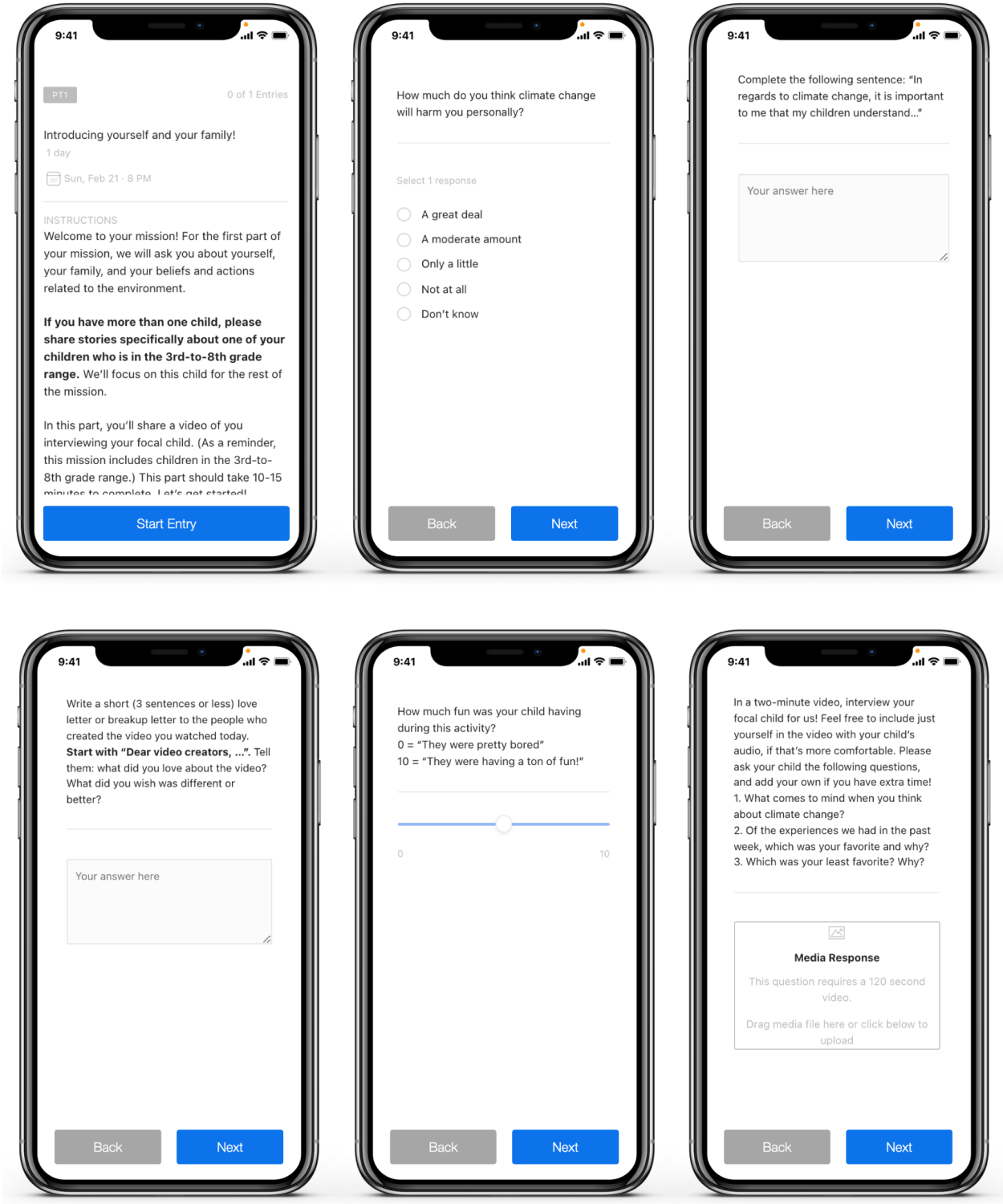

Figure 2. Screenshots of the diary study on the participant side using the dscout mobile app.

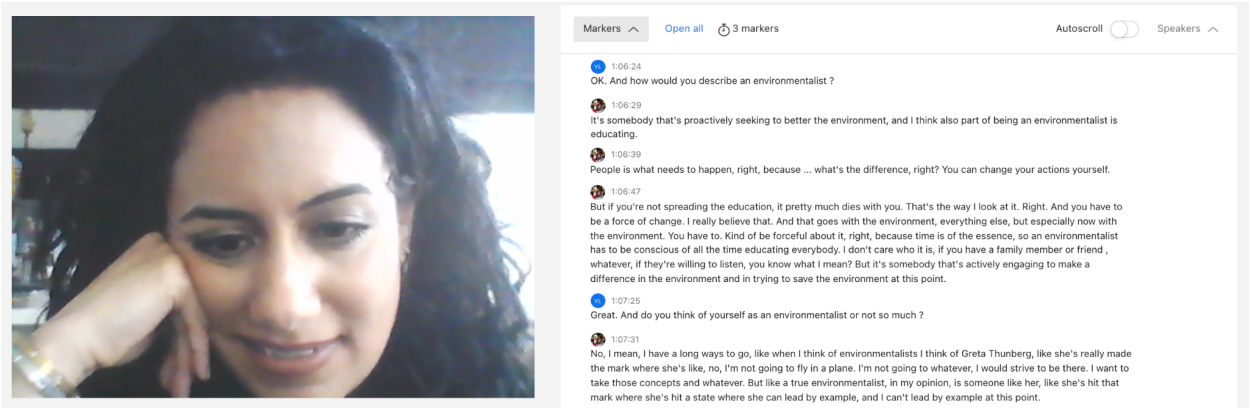

Figure 3: Screenshot of the Live interview tool on the researcher side of the dscout platform.

A dscout diary study has 3 primary elements: missions, parts, and entries. The “mission” is the diary study itself, a series of research activities that scouts (i.e. participants) are asked to complete. A mission is composed of several parts, where each part contains its own set of questions, instructions, and timeframe. Parts may require one or many entries, where entries are the answers that scouts submit. This diary study included 5 distinct parts, 3 requiring a single entry and 2 requiring multiple (i.e. two or more) entries. In the multiple-entry parts, participants were asked to engage in specific environmental learning activities with their child and report back on the learning moment; in each entry, they answered the same set of questions for a different activity. Excluding the required educational videos in Part 3, scouts submitted a total of 185 diary entries that each focused on a single learning moment.

Prior to building and launching the survey in the dscout platform, I pilot-tested different aspects of the protocol to validate clarity of instructions, quality of tasks and questions, and timing. Although the diary study was long (137 questions in total over the 5 parts), many parts were also repetitive, asking identical questions about the salient emotions, discussions, and learnings to allow for comparisons of different learning moments. I recruited 6 pilot participants (all parents with children in the 3rd - 8th grade range) to test a variety of components: one full part, specific prompts and questions, and the videos in Part 3. Because I was seeking feedback on the protocol itself, I conducted the pilot test using Google Forms, and separately tested the study in dscout with 2 pilot participants. The pilot results led to minor modifications in structure and wording, especially for the child-directed prompts. Based on pilot data, each entry was estimated to take about 10 to 20 minutes depending on the length of responses and speed of typing. Table 2 below shows an outline of the final protocol for the diary study. Each entry contained a mix of multiple-choice questions, scale ratings, open-ended text responses, image uploads, and video prompts.

Table 2. Data collection components for the diary study.

Component	**Requirements / deadline**	**Topics covered**
Screener questionnaire	[application only]	Demographics; IRB consent for research; opinions on climate change (e.g., SASSY); examples of environmental learning with child
Part 1: Introducing yourself and your family	1 entry over 1 day	About the family and focal child; actions and behaviors related to climate change; child attitudes and knowledge about climate change
Part 2: Learning about the environment	2 entries over 4 days	Reports of environmental learning moments, including: photo and verbal description; ratings of enjoyment and learning; motivations, discussions, emotions, and challenges
Part 3: Using tech to learn about the environment	2 entries over 4 days	Families were asked to watch two specific ~5 min educational videos, then report similarly to Part 2 in addition to a future projection exercise and a love letter or breakup letter to the video makers
Part 4: Choosing your own learning resource — sky's the limit!	1 entry over 2 days	One more environmental learning moment, this time utilizing any chosen resource; report includes same as Part 3, plus an explanation of the type of and motivation for the resource
Part 5: Reflecting back on the learning experiences	1 entry over 2 days	Caretaker and child reflections of favorite and least favorite learning moments during the study; opinions on climate change (e.g., SASSY); actions and attitudes related to climate change

For each entry in Part 3, participants and their children were asked to first watch a pre-specified educational video to learn about the environment and then to submit their responses on dscout. The video order was randomized for all participants, and communicated to them via direct message on dscout when Part 3 was released. The primary purpose of this part of the diary study was to assess how different families might engage with and respond to the same learning resource. The videos were selected from an original list of 47 total resources relating to the environment and climate change, including videos, interactive websites, books, articles and games. Each resource was tagged with estimated duration of engagement, topics and themes (e.g. water, waste, animals, etc.), and other pros and cons (e.g., child-friendly vs. not intended for youth audiences). I proceeded with a shortlist of videos because: 1) they are accessible to all with an internet connection (as opposed to physical books or digital resources that require certain

types of plug-ins or downloads); 2) easier to ensure consistency of activity duration; and 3) have a well-defined, research-backed set of characteristics to compare across (Corner et al., 2015).

The shortlist of videos, all approximately 5 minutes long, approached environmental education in a variety of ways: while some were animated, others featured live footage; narration styles included first, second, and third person; and a few utilized popular figures (like Bill Nye). In addition to creating a comparison matrix of principles for digital media on climate change (Corner et al., 2015), I also piloted the videos with 6 pilot participants. Their feedback demonstrated the emotional effect of each video: for example, one was seen as "inspiring and motivating," one was "depressing in parts" and "hard to understand," and another was "thought-provoking and informative." Based on the pilot feedback and the matrix, I selected two videos for the diary study participants to watch (descriptions from the video webpage):

1. "***Which bag should you use?***" by Luka Wright and Imogen Napper, through TED Education in Nov 2020 (link to video): *You've filled up your cart and made it to the front of the grocery line when you're confronted with yet another choice: what kind of bag should you use? It might seem obvious that plastic is bad for the environment, and that a paper bag or a cotton tote would be the better option. But is that really true? Luka Seamus Wright and Imogen Ellen Napper explore the environmental impact of each material. [Directed by Jody Prody, narrated by Bethany Cutmore-Scott].*
2. "***A love story for the coral reef crisis***" by Ayana Elizabeth Johnson, through TED2019 in April 2019 (link to video): *Over the course of hundreds of scuba dives, marine biologist Ayana Elizabeth Johnson fell in love -- with a fish. In this ode to parrotfish, she shares five reasons why these creatures are simply amazing (from their ability to poop white sand to make colorful "wardrobe changes") and shows what's at stake -- for us and them -- as climate change threatens the future of coral reefs.*

Ultimately, I wanted two videos that were similar in some ways (e.g. length, same platform, related to climate change, present scientific facts and a call to action) but different enough to allow for diverse interactions and responses (e.g. animated vs. live, relatability, topic, and emotional evocativeness). TED was the platform of choice, in part because it is a reputable organization with educational aims, and in part because YouTube contained elements like ads and auto-play that could alter the participants' learning experience.

The final piece of data collection was the semi-structured interviews (Saldaña, 2016), which were designed to be an hour in duration but ranged from 55 minutes to 1.5 hours. Prior to the interviews, I drafted a full protocol of interview questions and possible probing questions; see Table 3 for an outline of the protocol. A primary goal for the interview, in addition to reviewing

the learning experiences from the diary study, was to better understand the participant's relationship with nature and the environment.

Table 3: Outline of the semi-structured interview.

Component	**Topics covered**
Introduction	○ Rapport building ○ Agenda for the session ○ Consent for recording
Part 1: Family overview and impact of COVID	○ About yourself and your child ○ Family's relationship with nature (pre- and during the pandemic), including specific examples of activities for connecting with nature
Part 2: Diary mission overview and reflections	○ Highlights and anything unexpected about the diary study ○ Follow up questions on learning moment entries from Parts 2 - 4 of the diary study ○ Changes in thinking or action post-study
Part 3: Perspectives about climate change and action	○ Defining and discussing climate change with others ○ Defining and relating to the term "environmentalist" ○ Motivations and challenges for taking climate-related actions ○ How to support children learning about climate change
Wrapping up	○ Anything else to share ○ Thank you for participating

Procedure

Data collection for this study spanned 4 weeks in total from mid-February to mid-March 2021: 1 week for collecting screener responses and selecting participants; 2 weeks for completing the diary study, and 1 week for conducting the follow-up interviews. The diary study took an average of 15 days to complete, with the 58 participants ranging from 9 days to 24 days; they completed each part on their own time within suggested timeframes, and could not proceed to the next part until the previous part was finished.

Because the environment is closely intertwined with our lives as humans (e.g., weather, our surroundings, politics, etc.), it is important to consider the broader context of this study. Figure 4 below illustrates some of the relevant current events during this time; while some events directly impact perceptions and attitudes about climate change, others may have more indirect effects. For example, vaccine availability (which, in most states until March 2021, was limited to health care workers and those ages 65+), local case counts, and the intensity of the holiday surge could influence the types of activities that families felt comfortable engaging in.

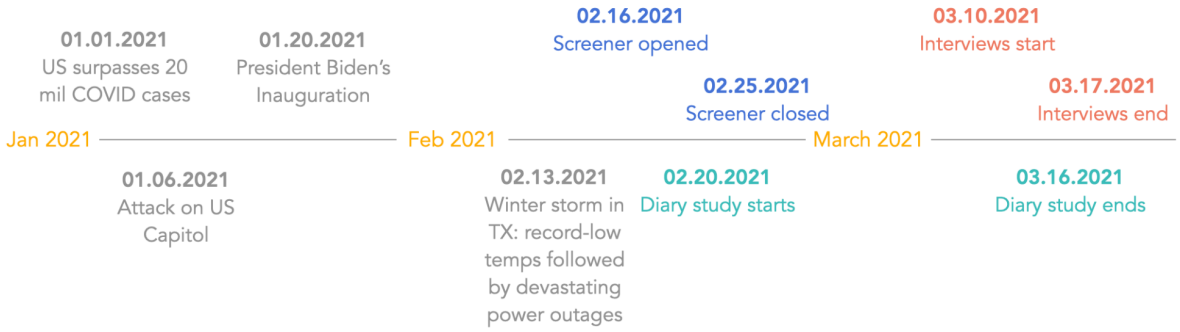

Figure 4. Timeline of data collection and relevant current events.

As the research facilitator, I released each part of the diary study manually (i.e. not on a preset automated schedule) to allow for a preliminary review of the responses and a chance to ask follow-up questions while still relevant. The dscout platform supports researcher-participant communication through two channels: 1) a direct messaging thread (which is general to the entire study); and 2) comment threads on each entry. Direct messages were used to introduce new parts of the diary study, highlight specific instructions, and remind and motivate participants when necessary, while entry-specific comments were utilized to assist with troubleshooting (i.e. issues uploading media), ask probing questions about a particular response, or share general commentary and provide a look for what to expect next.

Messages and comments were pre-written to ensure consistency of voice and content. For example, following their Part 1 entry, participants received the following comment: "*Hi _____! My name is Veronica, and I'll be your mission leader! Thanks so much for these thoughtful responses, and for the fantastic interview with your child. I'm looking forward to learning from you two in this mission, Part 2 will be open shortly!*" The dscout advisors suggested connecting frequently with research participants throughout the mission in order to increase the likelihood of valuable data: because diary studies are time- and energy-intensive and require a high level of commitment for participants, participant drop-off can be reduced with clear expectations, detailed instructions, frequent communication, and positive feedback.

To supplement the diary study data, I used qualitative interviews to provide further insights into the family's daily life, their diary entries of environmental learning moments, and additional perspectives about climate change and action. The interviews were coordinated and conducted remotely through live video on the dscout platform, approximately a week after the two-week diary study. A total of 13 caretaker interviews were conducted, and all interviews were video-recorded and transcribed, resulting in 85 pages of transcription. Following each interview, I

took 15 minutes to write structured memos reflecting on four areas: surprises, assumptions, what went well, and opportunities for improvement. I engaged in these retrospectives not only to help improve my own interviewing practice, but also to assist with analysis at a later time.

Analysis

Diary study responses and interview transcripts were analyzed using a mix of deductive and inductive coding (Saldaña, 2016; Strauss & Corbin, 1990). For some open-ended questions, such as one asking parents to reflect on their own pro-environmental behaviors, deductive codes were developed based on prior literature (Heimlich & Ardoin, 2008). For others, such as caretaker goals for children regarding climate change or reasons for discussing climate change with children, inductive codes were identified, refined, and applied. In addition, each environmental learning moment was coded for content and type of learning resource used. Throughout the coding process, analytical memos were written to record emerging themes and connections between codes. Following coding, which allowed for a systematic examination of the data, I aggregated codes, created summary case portraits, and selected illustrative case studies (Yin, 2009) to identify themes and patterns. This approach allowed for a representation of not only the primary trends, but also an in-depth analysis of the "how" and "why" for the learning moments and caretaker perspectives.

Preliminary findings

In this report, I present preliminary findings examining how families learn about climate change: (i) what adult caretakers want their children to understand in regards to climate change, (ii) how and why parents do or do not discuss climate change with their children, and (iii) what topics and resources are most approachable to families when engaging in environmental learning.

Caretakers' climate change-related goals for children

At the start and end of the diary study, participants were asked to "Complete the following sentence: 'In regards to climate change, it is important to me that my children understand….'" Three overarching themes emerged from their responses: the impact of action (67.2% of responses), the responsibility and obligation to take care of the planet (32.8%), and a consideration for future generations (19.0%).

Caretakers wanted to emphasize to children that their actions, both positive and negative, will have an impact. While some parents described different solutions, others highlighted the ability to make a choice:

"Even one family can make a difference by reducing waste, making environmentally responsible choices, and educating those around us." - 33 year old mother from IN with a daughter in 5th grade

"The impact of their actions and the products and services they use, and how everything fits together and the effects and consequences of different actions." - 44 year old father from IL with a daughter in 5th grade

"That it's an important issue and that there are things they can do personally to help the situation. How to evaluate different choices based on impact." - 43 year old father from MN with a son in 3rd grade

"That they/we get to choose how we live and it's up to all people to take actions to reduce climate change." - 40 year old mother from NY with a son in 6th grade

In addition, some parents, even those who were not concerned about climate change, felt that taking care of the planet was both a responsibility and an obligation for their children:

"He has an obligation to be a good steward for the earth and that his actions have implications for others." - 39 year old mother from NY with a son in 4th grade

"That it is important to take care of the things in our personal environment and to not be wasteful or careless, but climate change is not something that we should inconvenience ourselves or others over. It is not something that we should be obsessed over." - 40 year old mother from NC with a daughter in 7th grade

"That it is their job to leave the environment in good condition, clean up after themselves and make choices that help preserve it for future generations because that is what God intended for them to do." - 46 year old mother from WA with a son in 6th grade

Participants also mentioned future generations, including their children's own futures, as a motivating factor for action:

"That we only get one Earth, and it's our duty to maintain its future for us and future generations." - 29 year old mother from NC with a daughter in 6rd grade

"That we must change our behaviors now or there won't be a future for their children and grandchildren." - 52 year old grandmother from NV with a grandson in 4th grade

"That what happens today and in the future will affect them and future generations for decades and beyond." - 43 year old father from OH with a daughter in 6th grade

These findings reveal that regardless of their own stance on climate change itself, all parents can articulate climate change-related goals for their children. However, the points of view that caretakers exhibit in their responses suggest different underlying assumptions and approaches. Third person responses (51.7%) were most common, followed by first person responses (44.8%) and a small fraction of second person responses (3.4%).

First person perspectives illustrate a sentiment that the parent is on the child's side and ready to engage in solution-finding and change-making together:

> *"That it is real and it is an ongoing problem that will continue and get worse if the world doesn't change. That we need to do better. We at least need to get educated about what is happening in the environment to nature and to animals. The more we educate ourselves, the more likely we are to do better."* - 45 year old mother from PA with a daughter in 8th grade

> *"What we can do to help directly and through our $ and other support for companies and causes."* - 44 year old father from IL with a daughter in 5th grade

> *"Understand the effects it plays on our world today and how our grandchildren and great grandchildren will live by our choices now. How we should try harder now to make better choices."* - 44 year old mother from WA with a daughter in 8th grade

Conversely, second and third person responses appear to place the burden on the child and their generation, absolving themselves of their own generation's impact and responsibility:

> *"That every little thing ends up being a big thing over time and that even though you're one person if you spread the word educate or lead by example you can help take down a huge problem and eventually maybe even present a permanent solution."* - 44 year old father from OH with a daughter in 4th grade

> *"In regards to climate change, it is important to me that my children understand that it is not too late for them and their generation to make a difference!"* - 40 year old mother from OH with a son in 4th grade

> *"It is important to me that my children understand that they are the future and they have to put their part to make this planet clean and last for centuries to come. That things that they do today will impact their future when they're older. They are the coming generation and have to start doing their part and conserving energy and saving the planet."* - 39 year old mother from AZ with a son in 7th grade

> *"It is important for me that my child understands how vital it is to make changes now, so that they will be here tomorrow for generations to come. That he needs to do his part, and he needs to tell others to do their part to stop climate change, recycle, and save our planet."*
> - 52 year old grandmother from NV with a grandson in 4th grade

Frequencies of third person responses were highest for participants who believed that the primary cause of the world's rise in temperature was "mostly non-human related processes and cycles in the environment" (66.7%) compared to those who believed the cause was mostly human-related activities (51.4%) or an approximately equal combination of human-related activities and non-human related processes (41.7%). Although the number of participants in the "disengaged", "doubtful", and "dismissive" Six Americas segments were too small for comparison, the findings for the other three segments demonstrate a similar proportion of third person perspectives: "alarmed" (57.5%), "concerned" (44.0%), and "cautious" (64.3%). No statistically significant differences were found across child grade, child or participant gender, or participant ethnicity.

The differences in parents' points of view may be critical given that, as Lertzman (2015) and others (e.g., Schwartz et al., 2022) argue, solving the climate crisis requires a fundamental shift from individual to collective thinking (e.g., Lubell, 2002; Niemiec et al., 2016). The former can lead to what Lertzman describes as "climate disavowal," an awareness of the importance and urgency of climate change paired with a tendency or a choice to ignore the issue and place focus elsewhere. When parents engage in disavowal, they may unknowingly burden their children with climate-related trauma and anxiety: fixing climate change becomes their generation's responsibility.

Discussions about climate change: who, how, and why

Discussions are a central form of learning in the family unit, particularly when it comes to learning about the environment (Gould et al., 2019). To understand families' natural discussion behaviors, this study asked participants to describe what their climate change-related discussions entail and, for those who do not or rarely discuss climate change with their children, to share why that is. A nationwide survey in 2019 found that 45% of parents talk to their kids about climate change, despite 78% of parents believing that the world's climate is changing and 84% of parents supporting climate change being taught in schools (Kamenetz, 2019). Participant responses in this study demonstrated a slightly higher percentage compared to the 2019 nationwide survey: 8.6% of participants discuss climate change "often"; 56.9% "occasionally"; 27.6% "rarely"; and 4% "never". Qualitative coding of the participants' open-ended responses reveal statistically significant differences by ethnicity and child grade (Tables 4 and 5 below).

A chi-square test of independence was performed to examine the relation between ethnicity and the discussion of climate change. The relation between these variables was significant, X^2 (1, N = 58) = 4.32, p = .038, suggesting that participants of color were more likely to discuss climate change with their children compared to participants who identified as "white".

Similarly, the relation between the focal child's grade level and the discussion of change was also significant, X^2 (1, N = 58) = 5.91, p = .015. Caretakers with younger children (i.e. elementary school) were more likely to have climate change-related discussions with their children compared to caretakers with older children (i.e. middle school).

Table 4. Discussion of climate change with children, by ethnicity.

	White (n = 37)	**People of color (n = 21)**
Discuss CC	59.5%	85.7%
Do not discuss CC	40.5%	14.3%

Table 5. Discussion of climate change with children, by grade of focal child.

	Younger, 3rd - 5th grades (n = 33)	**Older, 6th - 8th grades (n = 25)**
Discuss CC	82.5%	52.6%
Do not discuss CC	17.5%	47.4%

Caretakers who reported discussing climate change with their children "often" or "occasionally" were asked to describe what aspects of climate change they talk about and what prompts the discussions. The most frequently mentioned topic was climate change-related actions (52.6%), followed by weather (47.4%), current events (28.9%), and animals (23.7%). Some conversations were also prompted by school assignments and curricula (23.7%), observations while outdoors (18.4%), and the child asking questions (15.8%).

Over a third of the participants recalled discussions about pro-environmental behaviors, including actions they have already taken as well as steps they could take. Examples ranged from substantial, one-time actions like buying an electric car to everyday behaviors such as conserving water with shorter showers, saving energy by turning off lights, and recycling; several responses also referenced the moments of change as a discussion starter:

"Usually these discussions occur when she asks about certain things such as why we're buying an electric car and why we control water usage." - 35 year old mother from NJ with a daughter in 3rd grade

"Usually the different actions we take prompt the discussions. When we collect our aluminum cans for recycling then we talk about why it's important. Or when we made the switch to cloth napkins from paper towels then we talked about the reason behind that decision." - 35 year old mother from IL with a son in 3rd grade

"Anything lol. All throughout our day we talk about things that we can work on. Turning off lights, not running faucets, not throwing away food, etc. We're starting composting and we showed how an apple and paper compost and how the plastic is in its exact form several months later." - 42 year old mother from VA with a daughter in 3rd grade

"These discussions come about as events in our lives prompt them. For example when the water gets left on while the kids are brushing their teeth or they are taking lengthy showers. Also, I frequently discuss the reason they need to turn off the lights, tv, video games when not in use. Another issue that prompts discussion is the need to close the door and not let the cold or heat in during extreme weather." - 52 year old grandmother from NV with a grandson in 4th grade

Many conversations about climate change were also initiated by weather, either observed firsthand or from the media. Climatologists have documented and reported on the increasing frequency and severity of extreme weather (IPCC, 2021), and such atypical weather patterns and events, both near and far, served as a source of discussion for many families:

"Drastic changes such as why there's no snow in winter and how come it's been 2 years without ample snow. Other times it's the opposite, why are things so cold when it should be summer time." - 44 year old father from OH with a daughter in 4th grade

"Recently it was the cold front in TX, wildfires in CA, etc. Evidence is everywhere and the news daily. If it wasn't for the covid pressure and mental load on my kids currently, I'd tell them more and was going in that direction until all of this happened. Now I feel like covid, the cold front, being without electricity (though I did mention this was a result of global climate change), its all overwhelming for a 3rd grader." - 41 year old mother in TX with a daughter in 3rd grade

"These discussions are sometimes prompted when there are severe weather changes. We often will discuss what's causing the weather changes and what we can do to take our part in saving the earth." - 39 year old mother in AZ with a son in 7th grade

> *"The recent polar vortex has been a hot topic at our house. We are used to these temperatures but the poor people in Texas are really struggling. We've talked a lot about how hard that must be and the things that we could do to help protect our planet!"* - 38 year old mother in MI with a daughter in 5th grade

In addition, conversations are sparked by current events, accessed by families through a variety of resources including cable news, radio stations, movies on streaming platforms, magazines, commercials, and social media:

> *"Usually what is happening in the news. When there are natural disasters or news of our participation in things like the Paris Agreement. We listen to NPR when our kids are in the car and we will talk about what we are hearing. My son also gets a magazine called The Weekly which is a round up of the news of the week and sometimes climate change is part of it. We watched the movie "I am Greta" recently too. We wanted him to learn more about climate change but also see that kids can make a difference."* - 39 year old mother from NY with a son in 4th grade

> *"Debriefing cnn10 when they show world impact issues like garbage patch in the ocean."* - 37 year old mother from OR with a daughter in 3rd grade

> *"Commercials and social media often spark these conversations."* - 45 year old mother from PA with a daughter in 8th grade

Across all child age groups, animals were another popular topic of conversation. In these discussions, families focused on the negative impact on animals and in some cases, behaviors to mitigate these effects:

> *"We talk about not being wasteful, recycling, not littering and cleaning up our environment. These conversations are often started by their love of animals and when we're on hikes."* - 34 year old mother from VT with a son in 5th grade

> *"We live by a lake and we always talk about how we can keep the fish and ducks safe from litter."* - 47 year old mother from GA with a daughter in 4th grade

> *"We mostly talk about the "popular" subjects such as the melting of the polar ice caps and the harm of mass amounts of human rubbish being strewn all over the world, in lakes, oceans etc., and its destruction of not only the overall environment, but also its harm to wildlife. (We are avid animal folks and even run a farm and animals rescue.) We have talked about the death of the coral reefs and the harm to the great barrier reef off of Australia due to human pollution and toxic climate change. We have talked about the polar ice caps*

melting and the harm that could cause in the future and is currently causing now." - 40 year old mother from OH with a son in 4th grade

"Wildfires, why the Arctic is melting and the effects it has on the animals who live there." - 36 year old mother from WA with a son in 5th grade

9 parents reported that their family discussions were inspired by what their children learned and talked about in school, illustrating the importance of in-school environmental education for intergenerational learning beyond the school context (Boudet et al., 2016; Damerell et al., 2013):

"*They have brought up declining sea ice and negative effects on arctic animals (I think they learned this at school), and we've talked about how increasing temperatures have affected the arctic significantly."* - 40 year old mother from NY with a son in 6th grade

"*The topic comes up a lot at home thanks to my son's school talking about it."* - 43 year old father from MN with a son in 3rd grade

"When coming up with schooling topics and projects. For instance my oldest did a project on the impact of Styrofoam." - 37 year old mother from OR with a daughter in 3rd grade

As prior research has shown, children's curiosity can drive learning (e.g., Jirout, 2020; Crowley & Callanan, 1998); many conversations were initiated by children themselves with "why" questions about certain decisions or patterns they had observed:

"So my daughter always wonders why the temperature is a certain degrees. We talk about it being hot in the winter on occasion, so that sparks conversations." - 40 year old father from OH with a daughter in 4th grade

"Usually someone asks why we do something. Or what can we do? Usually these discussions start with a question. Why do we do this? Or why don't we do this?" - 48 year old mother from AZ with a son in 3rd grade

"Certain times he asks why something is a certain way or I'll comment on something I see while we're out driving and that opens up a discussion about climate change." - 28 year old mother from NV with a son in 4th grade

For several families, being outdoors or away from home presented an opportunity for climate-related discussion. For some, conversation was sparked by beauty and nature; for others, it was the features of urban environments and the human footprint. These observations were often followed up with talk about actions for change:

> *"We also point out beauty in nature often when hiking, camping, and vacationing. We discuss how we can maintain this beauty for future generations."* - 33 year old mother from IN with a daughter in 5th grade

> *"Traveling and seeing large chemical plants and talking about what the smoke is doing to the environment. Seeing new electric cars on the roads and talking about how much safer they are for our world. We talk about what we can do to change our small part and what we hope to see in the future."* - 44 year old mother from WA with a daughter in 8th grade

> *"When we travel, we talk about erosion, litter, and how we can do better in this world. We see discarded masks in every parking lot and we try to pick up any litter that we see."* - 47 year old mother from GA with a daughter in 4th grade

Of the 58 diary study participants, 20 caretakers reported "rarely" or "never" discussing climate change with their children. Four themes emerged from their responses explaining why.

Some parents felt that discussing climate change was neither relevant nor important given other life priorities:

> *"Our kids are in middle school and high school and so many other priorities come up in our busy lives. We just don't get around to talking about issues like this!"* - 47 year old father from MA with a son in 8th grade

> *"It's not really impacting our lives."* - 56 year old mother from MO with a son in 7th grade

> *"It just doesn't seem to naturally make its way into conversation."* - 49 year old mother from NJ with a son in 3rd grade

> *"Life with multiple children amid a pandemic can get hectic, so some conversations aren't had too often. We tend to show by example more than we say."* - 29 year old mother from NC with a daughter in 6th grade

A few caretakers were not sure how to bring up the topic of conversation or lacked confidence in their ability to sustain the conversation:

> *"Even though I have read about it I don't feel well-versed enough to answer all of his questions."* - 45 year old mother from MO with a son in 4th grade

> *"I discuss climate change rarely with my child because I'm not really sure how. Usually we are watching a nat geo when the subject comes up."* - 36 year old mother from OR with a daughter in 8th grade

One parent shared that they expected their child to learn about the topic through other means:

> *"I guess I assume it will be presented in school as my teenagers seem pretty attentive if not more so than me."* - 44 year old mother from NJ with a daughter in 6th grade

A few other parents believed that their child was not interested or ready to discuss climate change, but still discussed taking care of the environment in broader terms:

> *"I am not a big proponent of the existence of climate change in the first place. I think the earth has existing periods of natural heating and cooling anyway. I have a traditional perspective of the earth's origins. We talk more about being good stewards of the earth and being responsible people, regardless of whether or not climate change is real. If we are good stewards, then we have less of a negative impact anyway."* - 46 year old mother from WA with a son in 6th grade

> *"I think our topics of conversation around nature and the earth tend to be about how we can leave no trace, but they don't focus on the climate or how the climate has changed. I'm not specifically avoiding the topic, I think it is very broad and not something my child is interested in."* - 44 year old mother from TN with a daughter in 7th grade

These results demonstrate a wide variety of approaches to discussing climate change with children. For many parents, it is a frequent topic that can be brought about by any aspect of everyday life: weather, school, news, or everyday actions such as showering or turning off lights. For others, however, climate change is perceived as a topic that is separate from daily life, something that requires additional expertise, time, and effort. By understanding what topics are salient for families that do choose to discuss climate change, as well as reasons why some parents do not engage in such discussions, we can begin to paint a fuller picture of the strategies and resources that might support effective family discussions about climate change.

Environmental learning moments: topics and resources

During the two-week diary study, each participating family was asked to engage in a total of at least three environmental learning moments of their choice, one of which required the use of a specific resource. Topics and resources varied across the 185 learning moments that were documented.

Parents and children learned about topics ranging from weather and natural processes to animals and climate change; the highest frequency topics are described in Table 6 below.

Table 6. Highest-frequency topics for families' environmental learning moments during the diary study.

Topic	%*	Description	Examples
Living organisms	21.6%	Families learn about or interact with living organisms, including insects, plants, and wild and domestic animals	*Her younger brother discovered a bunch of little snails, so we took pictures and watched them crawl around on the rocks for a while. It was pretty cool.* *We have been seeing a lot of deer around. We talked about why deer might be roaming around a lot. We have a nice big backyard so I thought it would be perfect to go try and find some deer footprints!! Me and my daughter walked around the perimeter of our yard and mentioned all the different types of tracks we found! … We also did some research on the computer to find out more info on deers once we found their tracks!*
Pro-environmental actions	18.4%	Families discuss, learn about, or engage in pro-environmental actions, defined as "actions aimed at avoiding harm to and/or safeguarding the environment" (Steg and Vlek, 2009)	*I printed out a list of 50 things we can do to learn about and protect the environment from environmentalamerica.org. We went through the list and picked the things my son wants to learn more about. He wanted to learn about "The Story of Stuff" so we watched the video and talked about it.* *We saw an article about birds that are entangled in disposable masks. Its recommended now to cut the strings before we throw them away. We talked about how it was unfair to nature and how people should do better.*
Science of climate change	16.2%	Families discuss or learn about different aspects of climate change, such as causes, evidence, news, risks, and mitigation strategies.	*We looked around the website and found games, activities and helpful articles that talk about how NASA technology tracks and studies climate change.* *We talked about how greenhouse gases work and what has an affect on CO2 levels. We discussed why we walk to the bus stop instead of drive.*
Weather phenomena	13.5%	Families discuss, observe, or learn about weather phenomena, including atypical weather, seasonal changes, and climate conditions locally and in other places.	*We talked about seasonal changes - how incredibly different the woods and snow seem as compared to even last week. The sun angle seemed higher, the sun felt brighter and stronger, the snow felt less dry and powdery and more wet and starting to melt in places. Our whole family was involved because we all went for a ski together at this state park nearby.* *My son and I were watching the news and he asked me about the weather in Texas last week. I try to explain what causes extreme weather in Texas and just so happen to come across an article online talking about the extreme weather. It was my son, my eight-year-old daughter, and myself discussing the weather. In the article it was saying*

			that scientists are predicting that if somethings not done in regards to global warming extreme weather is like this will continue to happen.
Spending time outside	9.2%	Families learn together while engaging in outdoor activities, such as hiking, walking, geo-caching, and other recreational sports (e.g., skiing).	*So basically there is like a creek in the backyard as well as vegetation and so we were exploring outside looking for known medicinal plants such as plantain, watercress, duckweed, etc. We were outside and decided to see if we saw some of the plants growing on the bank of the creek. We talked about how years ago people lived off the land and they didn't necessarily have to go to a doctor for their ailments, they went out in the forest to harvest medicine through nature. We also spoke about how sustainability is key to the progress of the earth and it staying healthy & unsustainability leads to imbalances that causes pollution, climate abnormalities, etc.* *We went for a walk on a nearby trail (through nine inches of snow!) on the hunt for some seeds, particularly burrs, for Evelyn to examine and learn more about. We talked a lot about the invention of Velcro and how it came from the inventor studying burrs. Evelyn mostly led the activity as she read all about seed dispersal in her science book.* *We talked about the different types of trees we saw during our walk. We both started talking to each other about how trees help the air.*

* Number of learning moments divided by 185, the total number of learning moments.

While 68.9% of families engaged with three different learning topics, 8.6% of families chose to learn about the same topic for all three of their learning moments. One family exclusively focused on climate change, one family enjoyed learning about the weather, and three families chose animals as their topic.

The proportion of topics are all comparable for the younger (3rd-5th grade) and older (6th-8th grade) children except for the topic “science of climate change”, which represents 19.5% of all learning moments for the younger group of children compared to 5.7% of all learning moments for the older group of children. Comparing the two groups directly, for all learning moments about climate change, 83.3% were experienced by younger children with only 16.7% experienced by older children. Table 7 below describes the differences by grade of focal child.

Table 7. Highest-frequency topics, by grade of focal child.

	Younger, 3rd - 5th grades (n = 33)	**Older, 6th - 8th grades (n = 25)**
Living organisms	57.5%	42.5%

Pro-environmental actions	55.9%	44.1%
Science of climate change	83.3%	16.7%
Weather phenomena	52.0%	48.0%
Spending time outside	58.8%	41.2%

For political affiliation, climate change is a more popular topic for parents identifying as Democrat (40.0%) or Independent (36.7%) than those identifying as Republican (16.7%). Democrats also engaged in the most learning moments about pro-environmental actions (47.1%) compared to Independents (29.4%) or Republicans (23.5%). The topic of living organisms, which covered plants and animals, was most popular for parents identifying as Republican (47.5%). Table 8 below shows the detailed breakdown of topics by political affiliation.

Table 8. Highest-frequency topics, by political affiliation of the adult caretaker.

	Democrat (n = 22)	**Republican (n = 16)**	**Independent (n = 17)**
Living organisms	30.0%	47.5%	15.0%
Pro-environmental actions	47.1%	23.5%	29.4%
Science of climate change	40.0%	16.7%	36.7%
Weather phenomena	44.0%	20.0%	20.0%
Spending time outside	29.4%	29.4%	41.2%

In the diary study, participants also described what resources, if any, they utilized during the environmental learning moments. Almost half of the learning moments included "conversation" as a primary resource for learning, sometimes as a standalone but frequently supplemented by other resources, such as videos, webpages, or books. Table 9 below reveals the highest-frequency resources utilized by participating families, as well as frequencies, descriptions, and examples of each.

Table 9. Highest-frequency resources utilized to support environmental learning moments during the diary study.

Resource	**%***	**Description**	**Examples**
Conversation	46.5%	Families engage in conversation together, either to debrief a specific experience	*We discussed all the different kinds of renewable energy and why they are better for our environment than fossil fuels. We also talked about the new technologies (some I didn't know about like human heated buildings and energy*

		(e.g., watching a video or reading an article), or to share observations, speculations, or knowledge.	*making sidewalks).* *As we were driving home tonight we were talking about the moon. We have been watching how it changes shape lately so we dug in to find out some more information on the reasons why. We explored things like gravity and fun facts about the moon. We went outside to look at the shape of the moon. We've noticed that each day keeps getting fuller!*
YouTube video	31.4%	Families watch one or more YouTube videos together about topics ranging from global warming to information about deers. Videos are viewed on mobile phones, computers, or smart TVs.	*We watched two short videos on YouTube that explained global warming/climate change in a way that is appropriate for kids (not too scary but still based on science and reality). The videos we watched were made by "crash course kids" and "hiho" YouTube channels. Crash course's video actually gave really good and appropriate information. Hiho's was more just clips of kids answering questions in little kids ways (a lot of "I don't know" and "global WHAT?!" Sort of responses). When we finished the videos, we sat and talked for a few minutes about what we'd heard. We all tried to think of ideas of ways we could reduce our carbon footprint.* *So today I took the kids to Reverchon Park in Dallas to feed the turtles like we normally do. Usually we see 30 + turtles but today we saw only 1 which was surprising, but then we remembered seeing on the news how turtles were freezing in the water because of the cold front and rescuers had to save them. We made the connection with climate change and global warming, showed her the litter inside another turtle pond and came home and watched 3 youtube videos about the story again and tied it into the Galapagos Islands and the litter issue there.*
Webpage	18.9%	Families access, read, and engage with webpages (including online articles) to learn about various topics. Webpages are viewed on mobile phones or computers.	*Since we live near the ocean and my son loves animals, we read about how pollution affects sea life. I read some articles to him while he looked over my shoulder and we talked about what we had read.* *We talked about all the fun facts about dogs! We laughed about some facts, were shocked at some facts and some were just plain weird! I read the websites out-loud to [my child]. We also watched the video "A day in the life" by the Beatles because apparently it has a frequency that only dogs can bear! We played it next to one of our dogs to see if he would react to the music-he was sleeping and woke up a few minutes into the song and looked at the phone strangely!*
Nature	18.4%	Families interact with various elements of nature while outdoors.	*During this moment my toddlers picked berries from shrubs while my 12 year old and I sketched trees without leaves on them. We talked about why some trees lose their leaves in the winter and why some don't.*

			We were looking at the first signs of spring! So excited that it is warming up and we can see flowers again. I was looking at the new blossoms with all of my kids and we were noticing how much earlier spring comes to the south compared to New England.
TV show / movie	10.3%	Families watch primarily entertainment-based TV shows or movies, mostly through streaming platforms.	*My son and I watched the Bear Grylls show "You vs Wild: Animals on the loose." We enjoyed discussing the options for Bear to rescue each animal and to check the power reserve. It was fun to see the tasks Bear could successfully tackle and what he could not do while facing the wilds in the animal preserve.* *Weather Underground television show on The Weather Channel.*
Book	6.5%	Families read physical books together. Some books are owned by the families, others are borrowed from the library or school.	*The kids heard an owl on our walk tonight and our 7 year old happened to have brought home a library book called Owls. So we read the book together.* *Learning moment involves reading one of our favorite books, the Usborne children's encyclopedia. She read the section about times and how it impacts nature. That book is unique and each section has a QR code that leads to a video about the same topic online, or additional reading. [My child] and I discussed the topic today.*

* Number of learning moments divided by 185, the total number of learning moments.

These findings illustrate the diverse resources that families leveraged to learn about the environment throughout the diary study. While some families turned to "traditional" learning materials like books and webpages, others found inspiration in natural resources outdoors, entertainment-based media, and their own knowledge and curiosity.

Participants also exhibited different patterns of using resources within individual learning moments and across the entire diary study: 32.7% of families engaged with multiple resources (e.g. a YouTube video and a conversation, or a book followed by a webpage) for all three of their reported learning moments, and 13.8% of families utilized only a single resource for each of their three learning moments. In the two examples below, the adult caretakers and their children engage in rich learning moments, each filled with different resources such as newspapers, videos, smart assistants, discussion, and hands-on activities to support and reinforce their learning:

> *"My mom gave me the local newspaper from this week. There was an article that a local arborist writes monthly in it. Last night I read it and it was about mason bees. I didn't even know that mason bees existed because I thought what we saw in our garden all the time were bumblebees. I thought [my child] would be interested in it since he is always in the*

garden with me. I had him read it over breakfast today before school. We talked about how useful and efficient they are as pollinators. After school I had him watch a short documentary video about them to give him more context. It talked about how to build places for them to nest, etc. we talked about each of the two activities after he was done reading/ watching. His father said we could build a nesting box if he wants to." - 46 year old mother from WA with a son in 6th grade

"We talked about how the environment and how the climate in our environment can have a good or bad impact. We asked Alexa for a definition of environment and then decided that watching a video about climate change would be fun. We quickly realized it would be better to see how change happens in a more relatable way. So we walked out to our garden and our potted garden to see what lack of water or sun or food can do to a plant. Our 7 year old helped by asking questions and showing us a plant that had wilted. We discussed that the environment for that plant was not good for it and it wilted. We moved the plant to a pot with more sun and water." - 48 year old mother from AZ with a son in 3rd grade

The 185 learning moments reported from the diary study revealed a diversity of ways in which families choose to learn about the environment in their everyday lives. These findings illustrate not only the topics and the resources that are most salient to parents and children, but also the creativity that families exhibit when learning together. The resources families leveraged included physical reading material, digital content, conversations, and elements of nature, and there were countless learning moments comprising multiple resources.

Next steps

This research has a long tail; the preliminary findings presented here are just a subset of the results from this research study and still require deeper interpretation and contextualization. Following a fuller analysis of the collected data, I plan to publish at least three journal articles, along with a report that details recommendations for practitioners in the field of environmental education: journalists, artists, educators, and scientists who work tirelessly to design and create experiences that sustain interest in, and motivate action for, our world. One article will focus on the findings presented in this report; a second will specifically examine the use of digital media in environmental learning; and a third will explore how adults generate ideas about climate change and sustainability given their identities as caretakers.

Ultimately, understanding how, why, when, and where parents and youth learn about environmental education in their everyday lives is just the beginning of an important exploration

into how best to engage diverse audiences in climate change-related experiences and conversations that are often political, difficult, and crucially urgent.

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