

Learning science while caring for pets: Findings from a virtual workshop for teens

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Abstract: Pets are beloved family members in many cultures. Companionship with pets motivates and positions humans as inquirers as they find out their pets' experiences with them. With the need to advance science education from dualist notions of the world and the learner as separate entities, our research team conducted a two-week online summer camp to engage teens and their pets in investigations around pets' senses. Following a qualitative analysis of participants' talk and projects at the workshop, we found that teens engaged in science learning practices while investigating aspects of their pets' lives and designing experiences for them. Additionally, participants adopted an ecological and relational approach to science learning that positioned themselves and their pets as subjects. We discuss implications for future work with pets, and for the design of other STEM learning environments that engage perspective-taking, empathy, and care.

Introduction

The field of K-12 science education values science content and scientific practices and endeavors to reach learners across socioeconomic boundaries to create a just and equitable society (National Research Council, 2007). Although most agree that science education is crucial to an informed citizenry, the field's view of what constitutes science learning is often restricted to thinking, acting, and practicing like a certain kind of a scientist. In the historically dominant view, a scientist represents a positivist objective view of the world and treats and studies nature in isolation using valuable skills such as conducting controlled studies while maintaining objectivity. Based on this view of what constitutes scientific work, K-12 science education typically encourages learners to use an emotion-free, impersonal approach to study the world independent of their lives and contexts. Although such a view of science education has produced promising outcomes for some science learners, its relevance and appeal to many others remain limited. There are other, less acknowledged soft skills such as a meaningful relationship with nature on which scientists rely that positions them as members of an ecosystem and affects the very depth and breadth of scientific knowledge. For example, Barbara McClintock's cultivation of a close relationship with the corn maize she studied that led to the discovery of transposable genetic elements (Keller, 1984) and primatologist Jane Goodall's research among families of chimpanzees in Tanzania is the basis of modern-day primatology research (Peterson, 2015).

As individuals, learners exist in relation to the world. To fully appreciate these relationships as rich contexts for science learning, we need knowledge and appreciation of contexts and inquiry skills where relationships are central. Engaging in inquiry with pets at home affords us this unique opportunity. We conjecture that humans' nurturing relationships with pets in a familiar ecology encourage teens to engage in holistic science practice. Based on this motivation, we infused a group of teens' home settings with Augmented Reality (AR) technologies to understand the sensory experiences of pets. Following this, we studied the teens' use of soft skills such as perspective-taking, care, and empathy in shaping their inquiry into the pets' lives. We designed our study as a two-week virtual workshop where teens engaged in tool use, investigations to understand their pets' preferences and behaviors, and experience design. In the following sections, we elaborate a theoretical framework, detail the study design and analytical methods, highlight a few initial findings and consider the implications of our work to the field of science education.

Theoretical Framework

Western scientific methods are founded on the principles of control, isolating study subjects and variables from their contexts, among others. These methods have led to scientific discovery and innovation in modern times, but have fallen short in solving some problems, such as environmental pollution. Such failures are noteworthy because products and methods of Western science are, at least in part, responsible for these problems. The lack of a viable solution indicates that a shift in thinking about and doing science is necessary.

The *Framework for K-12 Science Education* (National Research Council, 2012) and the Next Generation Science Standards (NGSS Lead States, 2013) aim to prepare students to learn particular science practices. However, there exist other holistic scientific methodologies from which learners could benefit. Overall, these

methods rely on what we know of the world in relation to the mutual, structural, and social interconnectedness of life where agency of all elements and multiple ways of knowing are key. For example, naturalistic methods rely on observing phenomena with minimum intervention (Boyd, 1980). Indigenous knowledge derives from the ecological interconnectedness of nature of which humans are but a member (Bang et al., 2013; Brayboy et al., 2008; Cajete, 2000). The principle of agency of all non-human elements of nature is instrumental to so-called posthuman (Pickering, 1995) and new materialist (Latour, 1987) methods. Common to these ways of knowing and doing science are at least two principles. First, nature and culture are inseparable (Haraway, 2003; Fuentes, 2010); an integrated, multispecies, contextual knowledge of nature benefits all. Second, there are methods, ways of knowing, and skills that privilege such intimate knowledge.

Donna Haraway's notion of naturecultures stresses the entanglement of the natural and the cultural, the bodily and the mind, the material and the semiotic. The reduction of the boundary between humans and nature, especially between humans and pets as companion species, is foundational to our study. As elements of natureculture, humans and companion species like dogs live in close association and the agency of both species is important; therefore, our interconnectedness rather than seeing other animals as objects of study is essential. However, any species of animals, including humans, are limited in perceptive capacities. Therefore, to inquire into animal sensory experiences, we must understand that sensory experiences are not uniform across the living world - each creature has its own "umwelt" (von Uexküll, 2001), a German term usually translated as "the world as experienced by a particular creature." Animal umwelts are unique in each of the five senses and are not accessible to us humans to a great extent, leading to various misconceptions and misunderstandings. Technology, especially AR, can broaden the window of sensory perception for users to better understand the natural world by overcoming the cognitive and biological challenges first by creating unique experiences and second by inquiring into those experiences. Doing so might allow us to adopt a relational and ecological understanding of animals' lives with humans by adopting the animals' perspective. Perspective-taking is the cognitive ability to consider the world from another individual's viewpoint (Galinsky et al, 2008) and has both perceptual and conceptual aspects. Perspective-taking based on direct observation and experience forms the background for empathy (the ability to connect emotionally with another individual) and care (the motivation to attentively rehabilitate through companionship and commitment).

The use of technologies in this way has implications for our understanding of human actions within the ecosystem as well. We need to move beyond the traditional conceptualization of learning ecology that recognizes a range of factors that affect the learner (for example, Bronfenbrenner, 1979) to include the learner and animals as active agents and in certain positionalities within the web of coexistence. Learning in this context implies valuing human-animal coexistence as a mutually reciprocal, dynamic, ever-evolving web of relationships. In our view, a workshop designed with such a goal could be the site where teen participants come to understand and define nature-culture relationships in their local contexts. Consequently, the workshop could help us understand how teens' soft skills such as perspective-taking, empathy, and care help them redefine science learning and related practices.

With this motivation, we answer two research questions:

1. How do teens at the workshop engage in the science learning practices of questioning, planning and carrying out investigations, and constructing explanations and designing solutions?
2. How do perspective-taking, empathy, and care shape the teens' science learning practices?

Methods

Overview of study

We structured this study as a two-week virtual summer camp that situated scientific inquiry and design work within adolescents' home environments with their pets. We designed this virtual camp with a mixture of synchronous and asynchronous at-home activities because of the COVID-19 pandemic. We shipped a box of materials to each participant that contained pet toys, treats, and craft materials to support their remote participation. During camp, we met with participants as a group for an hour each morning over Zoom to orient the participants to the tools and their use, and later asked participants to share their work from the previous day's at-home activities.

Recruitment

We recruited middle school and high school aged adolescents through a university-run STEM mailing list for youth who had previously engaged in STEM summer programs and were looking for similar experiences. The participants were between the ages of 13-18, had at least one dog or cat at home, and had internet and computer

access for the two weeks. Thirteen adolescents joined the program, along with 9 dogs and 5 cats. We examine the participation of the 11 participants who completed the study. All names used in this paper are pseudonyms. Each participant chose either one cat or one dog to be their main companion for the camp, with the exception of one participant, Riley, who participated with both of her dogs.

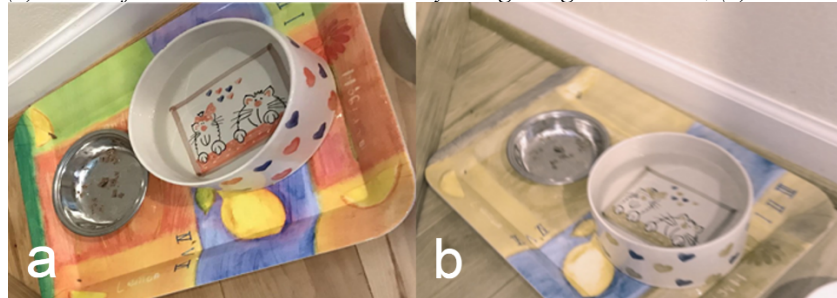
Camp activity design

Overall, we used research in the fields of human- and animal-computer-interaction, to develop the above-mentioned tools and the workshop plan. We designed the **first week of camp** to investigate their pet's senses and behaviors through the use of two tools - one, a set of two Snapchat filters called DoggyVision (DV) and KittyVision (KV; Authors, Year) that mimic the selective blindness of dogs and cats, two, a paper pinna modeled after canine and feline external ears and worn as human ear-accessories. The filters (the tools relevant to this paper) show the camera's view with an approximation of a pet's dichromatic vision making the images appear brown and dull, muted (Figure 1). At the workshop, participants were prompted to use the filter to photograph familiar objects and environments and to interpret how those images look relative to their own experience of it. Based on this observation, participants then planned their own investigations. In the **second week of camp**, participants worked on experience design projects that enriched some aspects of their pets' lives. Participants tested and evaluated their pets' interactions with their projects and conducted multiple iterations of their investigations and shared these to the entire group. In addition to these activities, we assigned a "Blog Prompt of the Day" which included prompts to write narrative journal entries from their pet's perspective, with the goal of connecting learning outcomes to perspective-taking and empathetic practices.

Figure 1

Images captured by a participant.

(a) A cat's food and water bowl on a tray using a regular camera, (b) and the KV filter.



Data Analysis

To begin the analysis, we observed five out of the ten workshop session recordings closely. We then created content logs detailing the participants' plans and actions as captured in their talk and photographic details of their investigations. Next, we analyzed the content logs for three specific Science and Engineering Practices (SEPs) as detailed in the Next Generation Science Standards (NGSS) for middle and high school-age learners. We chose three SEPs (Questioning; Planning and carrying out investigations; and Constructing explanations and designing solutions) to focus on in this preliminary analysis. In doing so, we explored these practices in depth while compromising the breadth of all eight SEPs. In parallel to this, we analyzed the content logs to identify instances of perspective-taking, empathy, and care. In the second round of analysis, we looked for SEPs informed by perspective-taking, empathy, and care and identified how they were connected.

Findings

We report two main findings. **First**, the camp design encouraged participants to engage in science learning practices, specifically, questioning, planning and carrying out investigations, and constructing explanations and designing solutions. **Second**, these science learning practices were rooted in perspective-taking, empathy, and care that serve the goals of science education.

Perspective-taking using tools

"I wonder why my dog's favorite toys are, like, not red." Wade (male, fifteen) wanted to find out why his dog Popper played with a select few toys. On what basis was the dog choosing these toys over the many others? As he photographed objects in and around the house using the DV filter, Wade noticed that red appears as green to dogs, which would mean that the red toys blend in with the grass when he plays fetch with the dog on the grass.

Surprisingly, despite not liking red-colored toys, the dog seems to like a red, white, and blue volleyball. Wade wondered how Popper perceived this tricolored volleyball differently from other solid red toys. Using the DV filter helped Wade understand why the dog does not play with red-colored toys on the grass, he thought aloud why can't dogs see red and green? By extension, what are the colors that would pop out in a dog's perspective and why? Further, if this is what his dog's vision constitutes, how might vision affect his dog's choice of toys? Wade's words indicate the direction of his inquiry - he wanted to find out the basis of the animal's selective colorblindness and how this unique sensory ability affects the dog. Wade's inquiry is situated in the careful observation of his dog's behavior and his willingness to enhance his dog's playtime experience. The empathy that he feels for the animal becomes relevant in light of what he has observed using the filter tool. When Wade compared what he observed in his dog's behavior every day with what the DV filter revealed to him, the pet's choices seemed obviously connected to the animal's sensory experiences. His attentive companionship shaped his questions. Siobhan's (female, fifteen) inquiry, like Wade's, is situated in close companionship, empathy, and care for her cat, Tigger. When Tigger rejects toys, Siobhan interprets the cat's response as different from a human rejection of a toy, i.e. not liking the toy for one or more reasons. Tigger's rejection of a toy could mean many things, from a lack of visibility in the current environment to a lack of suitability for play, rather than just dislike or a different preference. Wade concluded that if Popper could see a toy, especially as a ball, he would play with it, implying that Popper liked the ball as a toy. The only way for Siobhan and Wade to learn more about the pets is to interact with the pets intentionally and in close association and study the animals' behavior in different microenvironments within their home.

As the participants and facilitators continued to use and inquire with the DV/KV filters and what selective color blindness implies for their pets, Siobhan observed that her cat Tigger saw colors, primary and secondary, differently. For example, using the KV filter, she found that her purple sweatshirt looks closer to blue to her cat because Tigger cannot see the red in the purple. As Siobhan adopted the cat's perspective using the KV filter, she examined objects and colors of objects that are not immediately interesting to the pet, unlike a toy. Like Wade, she too examined her understanding of selective color blindness in the context of her cat's behavior and observed that her cat could not distinguish well between some shades of blue and purple, leading her to pay close attention to the colors her cat does prefer. Later, she wondered if the right color was enough for Tigger to like a toy. What if a toy was the right color, but not a suitable toy for play? The design and materials of the toys could be important factors too. What if Tigger could not play with it like he wanted to by batting it on the floor? Siobhan wanted to examine the texture of the cat toy materials to understand the cat's playtime as an experience that is affected by selective color blindness but constituted of many more factors including the sensory modalities of touch and movement. Using the filter gave them access into an area of inquiry. Using pet toys in slightly varying settings such as playing outside versus playing inside the home, and playing with different toys, and observing the pet's response, they extended their inquiry. Such a systematic inquiry initiated by tool use and intentionally extended in an everyday setting is a promising sign of science learning.

For both Siobhan and Wade, investigating pet vision through the filters led to an inquiry into pet vision in the context of play with toys where vision has a particular role. For example, if pets cannot see a toy such as a ball, if they cannot use the toy in a particular way, such as bat it or track it and chase it, they find it challenging to play with it. In this respect, playing with toys served as a meaningful context for inquiry into the sensory experience of vision, the animals' Umwelt, and the unique natural, material, and social ecosystem. Finally, Siobhan and Wade's inquiry was not just about pets' vision, but the pets' sensory experiences in an ecosystem they share with humans and interact with them.

Conducting investigations with pets

As the workshop progressed to the second week, the participants planned and conducted investigations to inquire how their pets would behave in a particular setting designed to understand their preferences and behaviors based on what they could see. Adrianna (female, thirteen) considered finding out her dog's favorite color, specifically, a favorite lacrosse ball color since her family buys packs of assorted lacrosse balls to play with the dogs. Adrianna was not sure that her dog, Wally, would choose the balls at all if he was not in the mood to play. Hence, she planned to smear all the balls with peanut butter and place them at an equal distance from Wally. Adrianna based her plan on the knowledge of her pet - the animal does not play with all toys equally, might not play on command, might need to be rewarded for following instructions from time to time, and has favorite incentives. She recognized that smearing all the balls with Wally's favorite treat, peanut butter, might result in Wally eating all the peanut butter negating the influence of a favorite color on the dog's choice. Upon recognizing this limitation in the setup, Adrianna sought to refine it or use a control rather than force Wally to act on command or take away the incentive. Although she wants to find out more about her dog's behavior, Adrianna is mindful of the animal's likes and dislikes in planning and carrying out her investigation. She recognizes that her investigation is not going

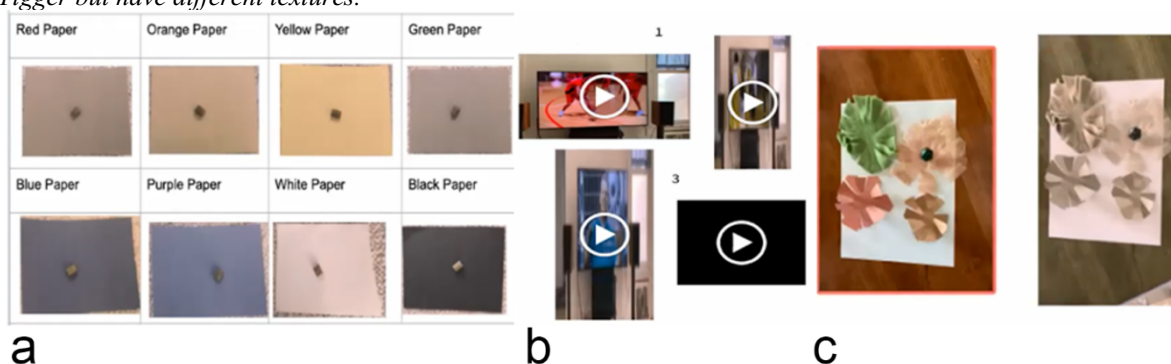
to be successful because of the use of peanut butter as a treat for the dog and she is open to considering other alternatives. Here, Adrianna's knowledge of her pet informed the design of her investigation, her understanding of dog behavior in general helped her evaluate and reflect on it. Her willingness to find out more about the animal and her desire to conduct a successful investigation motivate future refinements.

Evee's (female, sixteen) cat Saskia has a favorite treat. The treat is reddish-brown in color and Evee offers treats to Saskia on the light-brown wood-paneled floors. Using the KV filter, Evee has observed two things, first, that the treats appear as brown rather than reddish-brown to the cat, and second, they are close in color to the brown floor. Evee wonders if this is the reason her cat cannot see the treats very well. To find out a way to make the treat more visible to Saskia, Evee conducted an investigation (Figure 2a). She cut out small squares of construction paper in all colors of the rainbow, white, and black, and placed one piece of the favorite treat on each cutout. She placed the cutout-treat combination in an array and waited for the cat to choose one for each of the two iterations of the investigation. To her surprise, the cat chose the orange cutout-treat combination and consistently chose from the reg-orange-yellow-green row rather than the blue-purple-white-black row on both iterations of the investigation. Evee captured an image of the investigational setup using the KV filter to investigate the setting from the cat's perspective. Based on what she observed, Saskia's choice intrigued Evee. Evee expected the cat to choose the white cutout-treat combination because it appeared very close in color to the orange and yellow cutout-treat combinations. The treat stood out equally well against the yellow and orange, and moderately against the green and red. The treat stood out very well against the white cutout and yet, Saskia ignored it. Unable to explain Saskia's choice, Evee concluded that there could be other factors involved that influenced the outcome of her investigation. For example, was something other than visibility of the treat by virtue of color and contrast guiding Saskia's choice? Could smell be a factor? Evee recalled that often she needed to tempt Saskia with a sniff of a treat to lead her to her food and treats and once at the location, Saskia sniffed further before eating her food. She often missed treats that were farther away and Evee wondered if Saskia was acting out of habit as well as. Despite her meticulously planned investigation and an initial conjecture that the cat relied on smell only to guide her because she could not see her food well against the floor, Evee cannot accept Saskia's omission of the white paper-treat unit as the cat simply overlooking the treat. She felt the need for further inquiry into the combined effect of visibility, smell, and habit in Saskia's treat eating habits.

Figure 2

Investigations conducted by participants at the workshop.

(a) Evee's treat contrast investigation with treats placed on colored construction paper cutouts; (b) Luna's TV show investigation where she observed Rocco's reaction to different TV shows with and without sound; (c) Siobhan's color and texture investigation with Tigger where she chose colors that would appear the same to Tigger but have different textures.



Evee designed her investigation to make Saskia's experience of living in her home better for the animal. She wondered if it might be inconvenient for the animal to not be able to see her food and to not be able to seek food independently at home. This close observation of her cat and the commitment and affection she has for the pet drive her inquiry. In her narration of the investigation and its outcome, Evee was reluctant to call her cat disobedient or her investigation a failure; she accepted the cat's behavior and perception as factors she had to design her investigation around. Evee attentively observed Saskia and used the animal's response to the investigation to shape and elaborate her understanding of feline perception and related behavior. The investigation answered some of Evee's questions about Saskia's behavior and partially solved the cat's problem of not being able to see her food. Yet, new questions emerged and Evee demonstrated willingness to inquire further into Saskia's sensory experience.

Luna's (female, fourteen) dog Rocco likes to watch TV, and Luna wondered what aspects of the TV shows the dog liked the most. Using the DV filter, she rejected her preliminary hypothesis that the dog likes very colorful scenes; the scenes that appear colorful to Luna's human eyes appear pretty dull to the dog. Luna then considered that the dog probably likes scenes that include barking dogs and moving objects. To examine the effect of sounds versus sight on her dog's behavior, she muted the TV (Figure 2b). She observed a less enthusiastic response from Rocco - the dog did not jump onto the TV but still paid attention to moving objects such as basketballs. However, the dog was less willing to watch TV when the news was on, indicating that only certain sounds appealed to him. In a discussion during a group synchronous Zoom, another participant related how her cat refused to watch TV even when she turned on the nature channel and specifically pointed at birds. Luna shared that her dog had favorite TV shows. Siobhan added that her cat liked her iPad, especially when she played Minecraft on it. They wondered if moving objects and sounds attracted pets to TV shows and if all cats and dogs were attracted to these in the same way and to the same extent. These participants were surprised to learn that the color on the television screen made no difference to the pet – they learned using the filters that their pets' world was quite visually dull.

In her investigation, Luna carefully manipulated one variable at a time to understand what Rocco was responding to - sights, sounds or both. She found that her dog, and her friends' pets, had very particular tastes; they like certain sounds and sights and not others. In the context of this observation of Rocco's preferences and the findings of her investigation, Luna concluded that Rocco perhaps likes watching basketball and baseball because he liked balls. Rocco also liked playing with other dogs which explained why he got excited when other dogs appeared on the TV screen. Her experiment was carefully designed and implemented, and Luna relied on the findings of the investigation and her knowledge of Rocco's preferences to better understand why Rocco liked to watch TV. However, Luna's investigation did not require Rocco to do anything new in a controlled study condition, rather, Luna used a situation Rocco already was familiar with and liked to learn more about the animal. The findings of the investigation help Luna refine her understanding of Rocco's behavior, in turn, it makes Rocco's TV time more enjoyable as Luna knew what he liked best. The careful observation of the dog's everyday actions helped her design the investigation; the close companionship and commitment with her dog gave Luna a thorough understanding of the factors that were in play in the investigation and led to the outcome.

Siobhan's cat Tigger is full of energy and likes to play with toys, and at times, Siobhan finds it difficult to keep up with the energetic kitten. Her plan was to design a toy Tigger could independently play with leaving Siobhan enough time to attend to her schoolwork. Tigger liked toys that are visible to him and are easy to move across the floor so he can bat them. Siobhan noticed that the toys' visibility and movement across wooden floors contribute to the cat's willingness to play with the toy. So, she conducted an investigation to test the effects of textures on the cat's choice of toys by choosing fabrics that would appear close in color to Tigger but feel different to him (Figure 2c). To ensure that she would be studying the effect of texture only in her investigation, she examined several fabric pieces through KV to ensure that these would appear similar to the cat and ensured that the toys were similar in design. Siobhan designed her investigation specifically to test her hypothesis - her cat liked certain textures over others and needed to see the toy against a background. She controlled for the color of the fabric swatches in her investigation because using the KV filter she saw that most colors appeared quite dull to cats implying that contrast and visibility were more important than any particular color. She assumed that most toys looked quite dull to her cat and hence, other toy features must be attractive to Tigger and other animals. Her choice of toy design was evidence of her close observation of her pet, his tendencies and preferences, and her caring relationship with him. Although she wanted to conduct an investigation with the cat, the purpose of the investigation, the processes that the cat has to go through are incentives for the animal.

Overall, in this section we observed that the teen participants engaged in the following science learning practices (further details are in Table 1.). In the context of an AR-mediated tool use, they asked and refined questions about their pets' behavior (For example, Popper choosing some toys over others), they planned and carried out investigations to illuminate pets' everyday choices and habits (for example, Saskia needing to be hand-fed treats) and constructed explanations and designing solutions (for example, Rocco preferring some TV shows over others). The ways in which they carried out their inquiry revealed a strong sense of care and empathy towards their pet companions. In their investigations, the teens strived to be mindful of and uphold the animals' agency and living conditions.

Table 1

An example of science practices enacted by a participant with perspective-taking, empathy, and care.

Science practices	Enactment of practice	Enactment of perspective-taking, empathy, and care
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Questioning [Careful observation; Seeking clarity; Examining understanding; Determine relationships; Clarify and refine understanding] Planning and carrying out investigations [Plan and design to produce data; Produce evidence; Select appropriate tools; Manipulate variables and collect data] Constructing explanations and designing solutions [Make a claim; Construct an evidence-based explanation; Reason scientifically]	Luna: I was wondering why Rocco liked watching TV shows, so I filmed some of his favorite scenes from movies and shows. They did not have a lot of vibrant colors in DV but had a lot of dogs barking or a lot of motion. I muted the TV a few times and he ran up to the TV only when there were dogs running around. His favorite toy seems to be balls. When my mom turned on the news he went away.	Luna tried to understand her pet's preference for some TV shows. Understanding this helps her support a better life for the pet rather than assuming their likes and dislikes based on one factor. Using the DV filter she observed that most TV shows appeared very dull to the animal and she wondered if there were other aspects of the shows that attracted Rocco. She planned an investigation to find out what the pet likes to watch on TV and why. Luna had a thorough understanding of her pet's likes and dislikes and relied on this knowledge to plan her investigation. Most TV shows she uses for the investigation are those that the dog already likes. The pet's enjoyment is paramount and Luna does not force the dog to participate in the investigation when he walks away.
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Discussion

Ecological perspectives privilege our knowledge of nature as the function of at least two key factors - our interactions with the world and our positionality as just one element of nature. On the other hand, as users and practitioners of Western science, we presume a divide between the world as an object of study and the learner as the outsider individual manipulating the world for the sole purpose of gaining knowledge (Bang & Marin, 2015; Hecht & Crowley, 2019). Knowing about the world around us requires more than factual knowledge to include relationships within the ecosystem involving us and those with which we interact. Although such an undertaking might seem challenging, approaches such as the one adopted in this study can shape a change in a promising new direction.

Tools like the AR filters we describe here permit participants to experience the world as experienced by another species and serve as an invitation into another species' sensory experience. In doing so, these tools support a more profound, relational science learning, one that makes room for inquiry through perspective-taking, empathy, and care and builds on the learner's familiarity with and knowledge of their environment. In the above-mentioned instances, the human participants positioned themselves as equals to their animal companions, respecting and valuing their agency. When the animals choose to respond to some investigations and conditions and not others, the participants found ways to work with the animals rather than coercing them to act against their own interests. In fact, in the above examples, the animals were co-participants rather than research subjects. The human participants exercised their agency and so did the animals, making them co-participants and their relationship a subject-subject relationship. Further, the participants saw the animals' unexpected response to conditions and environments as relevant information that shaped their understanding of the animals as research subjects rather than an unexpected factor that negatively influenced their investigation and needed to be controlled. We wonder if the close relationship between the participants and their pet companions infused these investigations with affect and in doing so, contributed to rather than detracted from their success.

Conclusion

Overall, the findings above indicate that intimate knowledge of a pet at home is an excellent starting point for learning science. Further, as participants questioned the form, function, and scale of pet sensory experience, they situated themselves in an empathetic and caring relationship with the pet where the pet's agency was just as important as theirs. Their inquiry was situated in and motivated by this relationship. Such motivations and the soft skills of relating to them became relevant to learning science at the workshop. These observations lead us to the following refinement of what the science education community values as successful science learning. First, successful science learning experiences can take many forms rather than just one, stringently structured form of a closely controlled investigation involving defined variables. Eevee, Luna, and Siobhan's investigations did not resemble standard science investigations and yet, were rich contexts for learning, and relevant and meaningful to them as learners. Second, we need to broaden our understanding of what science learning constitutes. We see that

in the context of the workshop, adopting the perspective of another species, learning to be in an ecosystem by sharing agency are important aspects of learning that shape how and what we know as learners.

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