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Seeing Pollinators and Flowers: An Exploration of Families' Experiences Learning about Pollinators at and Outside of the Home

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Abstract: Building from literature connected to mobile learning and sense of place, this study explores the influence of place on families' experiences while using a mobile augmented reality app about pollinators that was designed to be used in outdoor spaces. From the second data collection of a design-based research study with nine families, we investigated the difference between two families' experiences completing the app at home or at a local park. This analysis demonstrates how families' sense of place interacts with the design of mobile augmented reality applications to influence the connections they make with their local outdoor settings and communities. Further attention to the sociocultural and political elements of sense of place within the design of a mobile augmented reality app could potentially help foster ecological stewardship actions and behaviors.

In Pennsylvania, native bees and other insects are important pollinators in parks and gardens, as well as the farms that make up much of the rural landscape. Through mobile learning, families can explore the areas in their communities where pollinators live, to see and learn more about them and their habitats. Based in a sociocultural view of mobile learning, learning is embedded within intertwining material, social, environmental, and individual contexts, and resources (Sharples & Pea, 2014). The design and affordances of mobile devices and mobile augmented reality (AR) applications allow designers to provide opportunities for learning in these community spaces (e.g., Kawas, et al., 2019). Our place-based mobile AR app was not designed for one specific location. Instead, it was designed to encourage learners to observe actions and meanings of outdoor places they are familiar with, such as their own backyards or neighborhood gardens or parks, that may not have been otherwise directly visible to them. Hence, families use the app to build on in their prior experiences of that place.

Conceptual framework: Sense of place

This research study builds from environmental and science education conceptions of Sense of Place (SOP) — the relation between people and place, which can help promote pro-environmental behavior and understanding of people's community or nearby environment (Ardoin, 2006). Increasingly in the learning sciences, pedagogical perspectives incorporate the concept of place to align discipline-specific practices and cultural practices in ways that are relevant to specific communities. With place in mind, science educators and learning scientists design learning experiences in ways that focus on the learners' multiple meanings of the place (Eijck & Roth, 2010) to establish pedagogies that are ecologically- and culturally-sustaining via on-site fieldwork (Semken, 2005), storytelling (Marin & Bang, 2018), and leveraging intergenerational relationships for funds of knowledge that support playful exploration communities (Bermudez et al., 2023). In our work with a mobile AR app about geological history (Zimmerman, Land, Faimon & Chiu, 2023), we found that social interactions within a specific place encouraged intergenerational sense-making conversations that led to deeper connections about families' communities.

Lim and Calabrese Barton define SOP "as a person's cognitive, affective, and embodied understandings of a place that are cultivated through a living ecological relationship" (2010, p. 329). There are four intersecting dimensions that make up the multidimensional SOP concept: the biophysical setting, psychological elements, sociocultural elements, and political economic elements (Ardoin, 2006). Ardoin defined the biophysical dimension of a place as the physical environment as well as the emotional connections that people make to the physical elements in that space. She described the psychological elements as related to how people experience a place, including a person's place identity, place dependence, and / or place attachment. The sociocultural elements were those related to a community's collective interactions and backdrops for understanding and interacting with a place. It includes a society's or microsociety's views and beliefs about a place. Finally, the political economic elements include the larger-scale and nested understandings and interactions within and about places. This can include connections to rules, regulations, and conceptions of ownership and stewardship. Ardoin describes these four elements as overlapping dimensions in a Venn diagram, reflecting how physical elements influence an

individual's understandings, which in turn make up smaller cultural group and larger societal group norms, values, and meanings.

Studies have also identified two components of SOP —place attachment and place meaning — that can be fostered through instruction combined with experiential learning (Chang, et al., 2015; Semken & Freedman, 2008). Research on SOP has shown that place-based education can help promote connection and understanding of community environmental issues (Zimmerman & Weible, 2017), and increase people's SOP and understanding of a location through long-term courses (Semken & Freedman, 2008) and AR applications connected to the history of a specific location (Chang, et al., 2015). Using the SOP framework, we investigate the following research question: *How do families' SOP influence their experience with an AR application about pollinators that was designed to be used in families' backyards, community spaces, or local parks?*

Methodology

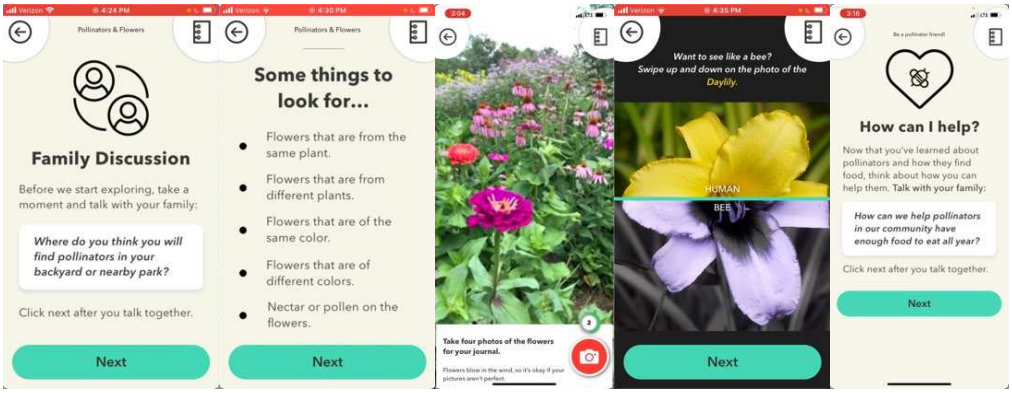
This analysis is situated within a larger Design-Based Research (Sandoval & Bell, 2004) study to create mobile AR applications for outdoor science education for rural families. This analysis focuses on the second data collection for one our AR apps called *Backyard Explorers*, investigating two families' learning experiences as they completed the app at home or at a local park.

Backyard App features

The Backyard App experience was approximately 15-20 minutes long and was split into three sections: (a) Pollinators and Flowers, (b) Seeing What We Can't, and (c) Be a Pollinator Friend. The app included various design elements (i.e., discussion prompts, guided photo taking, AR filters) that augmented the learning environment by providing resources connected to information relevant to the place and topic that may not have otherwise been visible to learners (Dunleavy & Dede, 2014). In *Pollinators and flowers*, families were prompted to discuss where they think they would find pollinators (Figure 1a), and then were encouraged to find and observe pollinators and flowers. The app offered families a list of behaviors to focus on while they observed pollinators (Figure 1b), asked them to take four pictures of pollinators (Figure 1e, f) and then asked them a series of yes/no "did you notice…" questions connected to the initial observation list. This was then repeated for flowers. Finally, families were prompted to observe a pollinator closely and take a 10-second video. In the next section, *Seeing What We Can't*, families learned about how pollinators and flowers interacted. This included an AR filter showing how some pollinators see the colors from UV light that humans cannot (Figure 1c), and an activity where families discussed pollination. The final section, *Be a Pollinator Friend*, prompted families to think about the kinds of activities they could engage in to promote pollinator wellbeing (Figure 1d).

Figure 1

Screenshots from the Backyard App



(a) (b) (c) (d) (e)

(a) family discussion prompt, (b) observation checklist, (c) photo taking prompt, d) bee vision slider, (e) stewardship family discussion prompt.

We did not design discussion prompts, text, or images that tied geographic, biological, or ecological phenomena to a specific location; however, SOP was included in the app in various ways. First, open-ended questions were provided to spark families' discussion where they could reference their observations, shared knowledge, and shared meanings associated with the place where they were visiting. Second, the app focused on common biological or ecological trends or behaviors, not one specific to a species or genus. Third, the end of the app

included some references to sociocultural and political economic issues related to pollinators (the value to agricultural crops and the stewardship of parks).

Data collection and analysis

These data were collected during the summer of 2021, via a social distancing protocol due to the COVID-19 pandemic. Nine families (7 from rural counties, 1 from an urban county, and 1 not reported) completed the mobile AR app experience (11 adults, 14 children). Parents or guardians self-reported their families mostly as White (White: 96%, White & Black or African American: 4%). Children (female: 50%, male: 50%, non-binary: 0%) were between the ages of 5-12. Of the eleven parents/guardians seven work in education (64%) and four self-reported other occupations (illustrator; HR; ecologist; disabled, not working). Two families (22%) homeschooled their children. Due to continuing restrictions from the COVID-19 pandemic, all families had to have internet access and an iPad or iPhone to participate (normally families can borrow equipment for in-person data collection). This limited our reach to families with their own technological resources for this data collection. We also acknowledge the assumptions of power and privilege present within our study, which was limited to mostly white families within rural counties that had access to and perceived safety in both public and private outdoor spaces where they could complete the app experience.

Primary data sources were the Backyard App screen recordings, which captured families' voices, app interactions and video from the photo taking portions of the app. Of the nine families that participated, only seven had complete video data. Additional data included: online demographic surveys and pre- and post-experience interviews conducted via zoom asking about pollinator knowledge and their experience with the app.

We conducted a qualitative analysis of the screen recordings using interactional analysis (Jordan & Henderson, 1995). Videos were professionally transcribed and confirmed for accuracy by researchers, and authors held co-viewing sessions to watch some of the videos. The transcripts were read and coded with the four dimensions of SOP (i.e., biophysical setting, psychological elements, sociocultural elements, and political economic elements [Ardoin, 2006]) in mind (Table 1). The coding occurred at the level of conversational excerpt (several turns of conversation) in the context of the full conversation occurring between family members. Only conversational excerpts related to the four SOP dimensions were coded. Initial co-viewing sessions, as well as individual viewing sessions done by the first author informed the selection of vignettes as exemplar cases that were chosen based on their overall engagement with the app and the SOP dimensions. Chosen vignettes were also compared to the results from the coding to confirm that the chosen families' experiences reflected the overarching experiences of the participants who used the app. These vignettes offer examples of how families used the app in different locations: one family who completed the app at their home and another who complete it at a park in their community.

Table 1

Sense of Place coding Framework Adapted from Ardoin (2006)

	Definition	Example
Biophysical setting	• Discussion of the physical environment • Emotional connections made to the physical elements of the space	11YOG: They're little like butterflies over here. Hi. The lily's blooming. Mom: Those flowers are dead.
Psychological elements	• Families' experience of a place (i.e., place identity, place dependence, place attachment)	Mom: Yeah. Mommy's always working on that, isn't she? I'm always asking daddy to buy more flowers and bushes and plants. [8YOG], any other ideas?
Sociocultural elements	• Discussion of collective/community interactions with the place • Society/community understandings, beliefs, views and norms for interacting in that place	Mom: Yes, I made- I'm working on my Penn State pollinator garden certification, so we actually are starting in the flowerbed area and I think we'll find some pollinators here.
Political economic elements	• Larger-scale and nested interactions and beliefs about places • Place as connected to rules, regulations, conceptions of ownership/stewardship and power	Mom: Seem to be a lot of bumblebees on *our flowers.*

Findings

While most families completed the experience at their homes (in their back or front yard), some families chose to do the app at a local park. Our findings below first examine SOP across the dataset and then transition to two vignettes — one each form a home setting and a park setting. For the two families in the vignettes chosen, the pollinators were the primary focus of their excitement and interest throughout much of the observation aspects of the app. However, families' interactions and engagement with the flowers and stewardship prompts varied depending on location, demonstrating how the app connected to the families' biophysical and psychological SOP and the individual and community impacts they felt they could have in their homes, neighborhoods, or parks.

Overall Trend regarding space for SOP in families' discussions

From applying the SOP framework to the families' discussions while using the app in their homes' outdoor spaces or in community parks, we found that families' utterances related to SOP in response to the app content was often about biophysical and psychological dimensions of place with some sociocultural references (See Table 2 for number of conversational excerpts). The political-economic dimensions were hardly mentioned; with the exception that the families often used the pronoun "ours" to refer to the garden or space visited.

Table 2

Number of Conversational Excerpts Related to Sense of Place

	Total number of utterances across all families	Average number of utterances per family
Biophysical setting	46	6.6
Psychological elements	12	1.7
Sociocultural elements	11	1.6
Political economic elements	7	1

When families discussed the biophysical dimensions of a garden, yard, or park, they often referenced their knowledge of the plants, animals, and abiotic elements present. Families all could identify where they would find blooming flowers, for instance, and many families had at least one person who could name various plant types by species, genus, or family (i.e., zinnias, clematis, speedwells, rhubarb). All families also discussed flowers in terms of physical descriptions rather than names, such as "there's a patch of little purple flowers" or "that purple spiky flower". Similarly, families often named insects (i.e., sweat bees, bumblebees, butterflies) but also referred to them in descriptions (i.e., "little, tiny fly bee things" or "it was teeny, but he was bright, bright, green").

Family members' psychological dimensions of SOP came out in a variety of ways as people discussed how they experienced their time together in the garden or backyard with the app. These elements were more subtle and expressed through laughter, exclamations of surprise, sharing of observations (i.e., "I think I saw it. I think I saw the tongue" [referring to a pollinator's probiscis]". Family members expressed their psychological dimensions in other ways too, for instance to have a commentary about their opinions of the things that lived in their yard: "Why are there no bees when I want to see bees? But when I don't want some, which is most of the time, they're everywhere." We did not find too many instances of storytelling (compare Marin & Bang, 2018) but we did find evidence of a family member narrating intent behind an insect's actions or anthropomorphizing the pollinators' behaviors (i.e., And, then the yellow jackets are like, 'mmm, I like this one. Nah, I'm going to go this one now'"). Related to storytelling, we did also find evidence of a few families making jokes about the insects. For instance, in one family the mother said aloud "there is a wasp on the mailbox", to which the father applied, "does that wasp have its mail delivered here, too? It picks it up on Saturdays."

The sociocultural dimensions of SOP were not as readily discussed by the families in the study as they used the app, but it did come out in two families' discussion about the values about what is growing their space: "Compare this area here to where there's a lot of just wild grasses or flowers and things to grass that's completely cut short. If you turned your entire property into just grass, is that helping the pollinators?" or we have a lot of grass that doesn't really have a purpose." Some families also mentioned learning opportunities related to their knowledge of pollinators (i.e., a documentary, pollinator garden certification).

The political economic aspects of SOP were discussed very rarely in this dataset, but they did come up when families talked about "our" garden and at the end of the experience when families were shown examples of the kinds of fruits and vegetables that farmers rely on honeybees or native bees to pollinate. While one of the last screens of the app suggested stewardship action families could do to help pollinators in their community, including asking their local parks organization or town to plant more native plants. Most families did not really discuss that political advocacy, except to say they have not or would not do that: (i.e., mother to her 12-year-old: "we haven't done that." and 11-year-old "Not talk to people, that's not something I would do.")

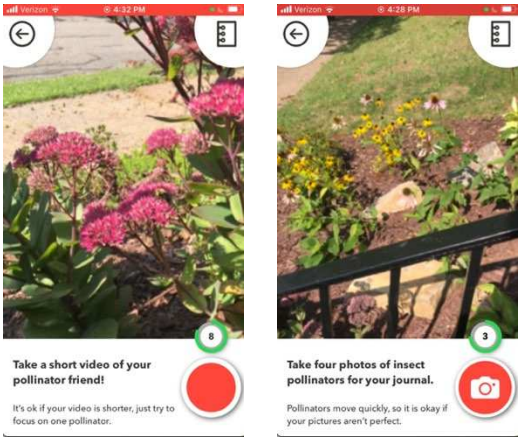
SOP at home vignette: Rebecca (Mother), and Sadie (10-year-old girl)

This case of learning outdoors at home shows how the AR components of the app provided an alternative lens for the daughter to view the flowers in her yard which encouraged deeper observation of her backyard garden and increased her excitement and engagement with the app. Rebecca and Sadie chose to do the app in their yard, where Sadie identified that they could find flowers (Figure 2). Connected to the biophysical dimensions of SOP, both mother and daughter demonstrated an understanding of the flowers in their yard and the pollinator garden Sadie's father maintained — naming specific flowers and locations in the yard where they might find pollinators. However, Sadie was excited by the pollinators, commenting on their behaviors as she observed and took pictures, instead of on the flowers themselves. During the flower observation activity Sadie did not talk about what she noticed about the flowers, instead she discussed the pollinators' activities:

> Sadie: "Observe the flowers. Now look closely at the flowers that are being visited by pollinators. What do you notice?" [Reading] Well, I noticed that… um…. Uh… [20 sec]. They're trying to sort of like stick their mouth inside the like flowers. Yeah.

Figure 2

Photos Showing the Front Garden where Sadie and Rebecca Completed the App Experience, including Flowers and Pollinators They Observed



Later in the app experience, during the AR filter activity showing how bees see flowers differently from humans, Sadie was excited about seeing the flowers and connected the app content to something that her father planted. As they talked about the daylilies (Figure 1c), Rebecca connected what she saw in the app to what she saw in their yard by pointing out the daylilies and the location of the pollen on them.

> Mother: Yeah. Daylilies.
> Sadie: Oh, this is like one of dada's daylilies. It's purple and it's yellow for us. That's funny. Really cool.
> Mother: That's that one right there.
> Sadie: That one? Yeah.
> Mother: It's that yellow one.
> Sadie: So there's pollen on the outsides?
> Mother: Uh-uh ((negative)). [crosstalk]
> Sadie: Oh, no. The black [on the inside of the flower] is the [pollen location] ... Yeah. That makes sense. Super cool. There's another one.

For Sadie and Rebecca, their pollinator garden was an everyday aspect of their life. When she was able to see the flowers in her yard through a different lens, she became more interested in thinking about the flowers, pollen, and nectar in her family's pollinator garden.

Doing the app at her home also allowed Sadie to see and connect the actions her family was taking in planting flowers with the content of the app. When doing the last section, *Be a Pollinator Friend*, Sadie was able to make connections between the pollinator stewardship suggestions in the app, and what her family was already doing to help pollinators through her father's native pollinator garden.

Sadie: "How can we help pollinators in our community have enough food to eat all year?" Um, well, we have a bunch of flowers in our yard that help, um, pollinators. This is [Father's] pollinator garden, right?
Mother: Mm-hmm ((affirmative)). This is. And he's started another one up in the corner.
Sadie: Yeah.
Mother: And he's been trying to plant native plants that helped the native pollinators.

This conversation helped Sadie to connect her families' actions to what she had been learning, as she later remarked that they were "doing good things" for the pollinators. However, Sadie and her mother's discussion of the ways their family were helping the pollinators and local ecosystem focused on their own garden, not engaging with the community stewardship suggestion of "asking your park to plant more flowers", with Sadie saying: "We're probably not going to do that", and her mother echoing that they were focusing on their own yard.

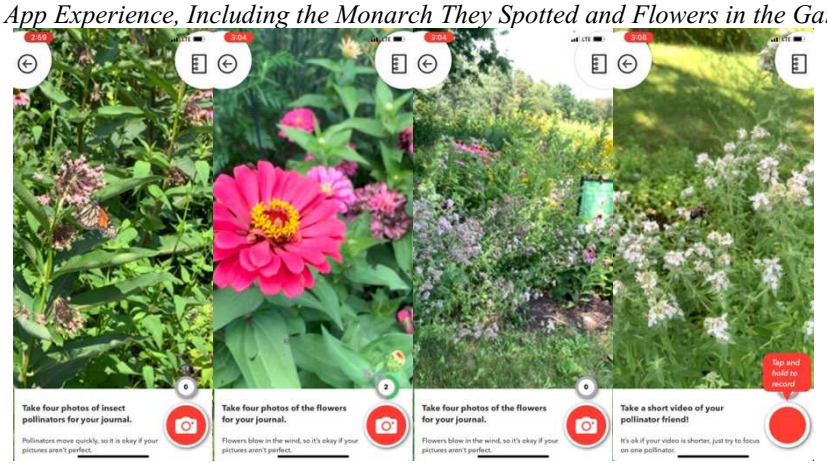
SOP at a Park Vignette: Wendy (Mother), Aubrey (11-year-old girl), and Cameron (7-year-old boy)

For this family who completed the app experience at a park, the app's features allowed them to connect to multiple places within their community and helped to foster their interest in observing local flowers while taking pictures and looking at pollinators. Wendy, Aubrey, and Cameron decided to do the app at a local park with a fairly large native wildflower pollinator garden (Figure 3). They were immediately interested in the bees, butterflies, and flowers at the pollinator garden. As they went through the tour, Wendy prompted her children to think about how they could connect what they were learning and observing at the park to the flowers and pollinators by their home (i.e., "So if it wasn't at [Park name] Butterfly Park, where else might you see pollinators? What do you see here that is also similar to what's in your backyard or your front yard?").

Aubrey and Cameron demonstrated their interest in the flowers as they moved around the garden and commented about the different flowers and pollinators during the flower observation activity (Figure 1f), with Cameron later talking about how the sunflowers he saw were his favorite flowers. Wendy also continued to prompt them to discuss and elaborate on what they were seeing.

Cameron: Look... Is that the same monarch on that flower?
Aubrey: Yes. He's resting on it. All right. Next. Some things to look for, flowers that are from the same plant. Yes. There's multiple flowers on the same plant.
Mother: Like that right there.
Aubrey: Yeah, there's multiple. Okay. Flowers that are from different plants. Yes, we see a variety of flowers, I think is what they're asking.
Mother: Like the big tall ones back there, that might be what we have by the mailbox.
Aubrey: Oh my. Flowers that are the same color. Yes-
Mother: What do you see, lots of what?
Cameron: Yellow.
Aubrey: Purple and yellow.

Figure 3
Photos Showing the Pollinator Garden where Cameron, Aubrey and Wendy Completed the App Experience, Including the Monarch They Spotted and Flowers in the Garden



The family continued to show excitement and interest in the content of the app as they moved through the next two sections. As they discussed what behaviors they could do as a family to help pollinators, Aubrey noted that they could plant flowers in their own yard, but the family connected the question "do you think your park could plant more flowers" to the park they were currently at, noting the large amount of flowers present in the pollinator garden space. Aubrey's comment that this park could not plant more flowers, presumably because there were already so many, but that they could choose a different park, demonstrates how the families' sense of place toward their local park was tied to their current individual experiences of the park, rather than the sociocultural elements present in community members caring for this pollinator garden throughout the year.

> Aubrey: What would you try? Did your family come up with any of these ideas? Pick ones you'd like to try…. Plant flowers in my yard, we said that. We said plant different kinds of flowers. We said, plant flowers that bloom different times a year.
> Mother: Do you think your park right here could plant more flowers?
> Aubrey: I don't think so, to be honest. I think if they plant more-
> Cameron: No.
> Aubrey: I think we'd have to choose another park, but we could do that.
> Cameron: Most definitely.

For Wendy, Aubrey, and Cameron, the park offered a place for them to explore the flowers that they might not see every day in their own backyard. Their experience of the app was rooted in the space they completed it in, from their excitement in exploring the pollinators and flowers at the park's garden to their comments about asking a park to plant more flowers. Additionally, while the family may have been familiar with this park at different times of year, their experiences seemed somewhat individually and temporally bound to what flowers existed in the park currently, instead of what was grown or planted over time.

Discussion

The site independent nature of our mobile AR app allowed families to choose the place where they would like to complete the experience, leading to families observing pollinators in areas that had different potential meanings and SOP. Within the app experience there was a strong focus on the interaction between individual's experiences (psychological elements) and the biophysical setting they were completing the app in, encouraging families to engage with the psychological and biophysical elements of SOP. For Sadie, the AR components of the app provided a different lens to view the flowers in her yard which, connected to her psychological SOP, increased her excitement and engagement in the app and in observing her home garden. For Wendy, Aubrey, and Cameron, completing the app at a local park allowed them to connect to multiple places within their local community and helped to foster their interest in observing local flowers while taking pictures and looking at pollinators. While not all families engaged with the sociocultural elements surrounding the upkeep of communal pollinator gardens, parks or even family gardens, the stewardship prompts at the end of the app encouraged families to consider ways that they could contribute to their community and expand their sociocultural and political SOP. Our app only minimally mentioned the political economic elements of environmental stewardship towards the end of the experience (in relation to the value of pollinators to agribusiness and how families could make environmental stewardship decision in their community). Strengthening this aspect could enhance community-based learning as well. While families stated individual actions that their family could take or was taking when prompted by the app, they did not engage strongly with the broad community stewardship prompts (echoing other research, Zimmerman & Weible (2017)). By completing the app at their house, Rebecca and Sadie were able to connect the actions that her family was taking to help pollinators and their environment to what she had learned about in the app. Alternatively, while Wendy, Aubrey and Cameron were able provide broad actions they could do to help pollinators when prompted, they did not provide the same emphasis on how their actions were or could affect the place that they were observing, especially as the garden seemed wild and overgrown to them.

While the small sample size limits the generalizability of our findings, this analysis adds to previous literature related to how families and learners interact with and understand place with an outdoor mobile AR app. This analysis also provides implications for designers of place-based mobile learning experiences when the app is designed to be used in various types of outdoor locations. Connecting with previous research (Chang, et al., 2015; Semken & Freeman, 2008) we found that a combination of information content and place-based experiential activities helped foster engagement in learning about pollinators and their habitats, especially in places where families are familiar or often present. Providing alternative lenses for families to view places through may also

encourage connections and engagement with inanimate objects (flowers) in addition to animals that can help foster their SOP and potential stewardship toward these environments. In places outside of the home where families are familiar, designers can help foster already existing connections to families' homes and the space(s) they are completing the app experiences to expand their understanding of the different and diverse landscapes with which they may interact. A focus on the sociocultural dimensions of SOP as well as families' place attachment and meaning within certain biophysical settings, could help increase or foster stewardship and connection to their community's environment and those that live there.

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