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Words Matter: Empathetic Interpretation Can Increase Children's Positive Perceptions of a Disliked Insect

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ABSTRACT

Informal science education presentations offer a promising avenue for conservation education. Understanding how to cultivate empathy for animals, particularly species viewed negatively, can help design programs that promote compassion towards animals, strengthen connections to conservation, and enhance conservation efficacy. This study used a pre/post Personal Meaning Map method to evaluate changes in children's attitudes, empathy, and knowledge. We investigated the effects of two types of interpretive conservation presentations (ecological or empathetic) on children's personal meanings (empathy, attitude, and knowledge) toward cockroaches. Summer camp children (7–12 yrs) were randomly assigned one of two interpretive presentation styles: (1) an ecological knowledge-focused presentation, or (2) the same information presented in an empathetic style. A total of 332 words/phrases were recorded from 12 camp sessions, with 180 participants. The word cockroach had fewer negative associations after both presentations, suggesting that either style of presentation reduces children's negativity towards cockroaches. However, positive and naturalistic associations only increased after the empathy presentation, suggesting that a larger positive shift is achieved using an empathetic presentation.

1 | Introduction

The public perception of animals is directly linked to conservation success (Kellert 1993; Caro et al. 1994; Ceríaco 2012; Estren 2012), with well-liked animals receiving increased funding (Ceríaco 2012; Colléony et al. 2017), research (Ceríaco 2012; Colléony et al. 2017), public support (Liordos et al. 2017), and positive media attention (Clucas et al. 2008; Geest et al. 2022) over disliked animals. However, negative attitudes and perceptions of animals can change through increased education exposure (Caro et al. 1994; Rule and Zhbanova 2012). Thus, any program that can increase understanding and positive perception of lesser-known or disliked animals through connection with nature (Vaske and Kobrin 2001) or emotional connection to animals (Myers et al. 2004; Grajal et al. 2017) has the potential to increase wildlife conservation efficacy.

Informal science education presentations, regularly used in zoo and aquarium settings, offer a promising avenue for conservation education that could strengthen human connections with disliked animals (Mann et al. 2018). Often the goals of such programs are to increase biological knowledge about the animal and to inspire conservation action (Ballantyne et al. 2007; Gusset and Dick 2010; Falk 2014; Mann et al. 2018). Though conservation-themed programs have been shown to increase audience knowledge (Ballantyne et al. 2007; Gusset and Dick 2010; Falk 2014), there are mixed results regarding whether participants actually adopt behaviors that support conservation after the program (Adelman et al. 2000; Kemmerly and Macfarlane 2009; Macdonald et al. 2015; Mann et al. 2018). However, studies examining the impact of conservation-themed programs on pro-environmental awareness, attitudes, and behavior often overlook changes in audience empathy and attitudes towards animals.

Empathy is directly connected to an individual's desire to take conservation action (Berenguer 2007; Chawla 2009; Kals et al. 1999; Akerman 2019). Empathy is a comprehensive emotional state

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Summary

This study tested how two conservation presentations shifted children's attitudes, empathy, and knowledge about cockroaches. Both reduced negative associations, but only the empathy presentation increased positive and naturalistic views.

composed of three parts: affective empathy, cognitive empathy, and empathic concern. Affective empathy is when an individual experiences the emotions of another as if it were themselves (Myers and Saunders 2002; Myers et al. 2004; Myers 2007). Cognitive empathy is when an individual can imagine themselves in another's reality (Myers and Saunders 2002; Myers et al. 2004; Myers 2007), whereas empathic concern is the desire of an individual to relieve others of suffering (Pfattheicher et al. 2016). In the context of animals, each type of empathy provides an opportunity for an individual to connect with an animal on a deeper level (Myers and Saunders 2002; Myers et al. 2004; Myers 2007, Cuff et al. 2016; Eres et al. 2015) beyond simply gaining knowledge. This connection can also extend to an awareness of conservation needs and inspire action (Skibins and Powell 2013; Cox and Gaston 2016; Howell et al. 2019; Clayton et al. 2009; Kleespies et al. 2022).

One strategy used to foster empathy, often in educational interpretation, is anthropomorphism. Although anthropomorphism is sometimes critiqued for oversimplifying or misrepresenting animals, it is also widely used in informal education settings because of its potential to increase relatability and emotional engagement (Myers and Saunders 2002; Myers 2007; Owen and Aquarium 2015). Empathetic interpretive strategies may include light anthropomorphic framing (e.g., naming animals or describing familial roles) to help shape children's emotional associations with animals. Because interpretive approaches differ in the degree to which they engage affective versus cognitive processes (Kals et al. 1999; Myers 2007; Chawla 2009), it is important to examine whether presentation style plays a role in shaping children's personal meanings of animals. Similarly, considering personal attitudes towards animals is important for understanding how people perceive and connect with animals on a broader scale. Kellert (1984) developed nine attitudinal scales to evaluate attitudes towards animals: naturalistic, ecologistic, humanistic, moralistic, scientistic, aesthetic, utilitarianistic, dominionistic, and negativistic. The naturalistic scale measures interest and affection for wildlife/outdoors (Kellert 1984). The ecologistic scale measures concern for the environment and interrelationships between wildlife and habitats (Kellert 1984). The humanistic scale measures strong affection for individual animals, primarily pets (Kellert 1984). The moralistic scale measures concern for animals regarding welfare/well-being (Kellert 1984). The scientistic scale measures interest in the physical attributes and biological functions of animals (Kellert 1984). The utilitarian scale measures the economic value of animals or their habitats (Kellert 1984). Dominionism is related to the mastery and control of animals, particularly within sporting situations (Kellert 1984). Finally, the negativistic scale measures avoidance of animals due to negative attitudes or passive indifference (Kellert 1984). These attitudinal scales have been used to evaluate attitudes towards animals in multiple studies (Kellert 1976; Kellert 1980; Kellert 1991; Caro et al. 1994), including studies focused on both children (Kellert 1984) and adults (Caro et al. 1994).

A novel and underutilized approach to exploring empathy and personal attitudes toward animals is to examine public perceptions of insects (Lemelin et al. 2016; Lemelin et al. 2017). In general, public attitudes toward insects are mixed. Butterflies (New et al. 1995; Lemelin 2007), lady beetles (Lemelin et al. 2016), fireflies (Bascom 1979; Schuettler 2007; Haugan 2019; Lewis et al. 2020), and dragonflies (Schlegel and Rupf 2010) are often viewed positively, whereas wasps and ants tend to be perceived negatively (Bart 1972; Kellert 1993; Woods 2000; Breuer et al. 2015; Lemelin et al. 2016; Lemelin et al. 2017; Geest et al. 2022).

Despite the public's ability to easily recognize cockroaches (Lemelin et al. 2017), they are particularly detested (Wagler and Wagler 2011; Lemelin et al. 2016; Wagler and Wagler 2021), to the point of being deemed 'children of filth' (Lynd 1921; Sumner et al. 2018; Jose 2019). Despite the public's negative perception of cockroaches, the Madagascar hissing cockroach (*Gromphadorhina portentosa* Schaum) has become a popular insect in educational settings because it is wingless and docile (Morgan et al. 2007; Wagler and Wagler 2011; Wagler and Wagler 2021). Although Madagascar hissing cockroaches were once only endemic to the island of Madagascar, they are now a common insect in the pet trade and can be easily acquired by educational professionals across the United States (Bell 1981; Morgan et al. 2007). Additionally, Madagascar hissing cockroaches produce a characteristic hissing sound and may have the ability to discriminate between people, which adds interesting elements to educational presentations (Bell 1981; Clark and Moore 1995; Davis and Heslop 2004). The ease of access and docility of this species, combined with the public's generally unfavorable view of cockroaches, make the Madagascar hissing cockroach well-suited to interpretative presentation evaluation (Wagler and Wagler 2021).

Understanding attitudes towards animals and designing educational programs that foster empathy has the potential to increase conservation awareness and ultimately improve overall conservation efficacy. This study investigated the effects of two types of interpretive educational presentations (ecological or empathetic) on children's personal meanings (empathy, attitude, and knowledge) toward an insect using cockroaches, which are often viewed unfavorably by the public. Prior research suggests that empathetic interpretation can increase emotional affinity toward animals, whereas informational presentations primarily influence cognitive understanding (Kals et al. 1999; Myers 2007; Chawla 2009; Young et al. 2018). This contrast provides a rationale for examining whether the two presentation styles influence personal meanings in distinct ways. The aims of this study were to investigate how personal meanings of cockroaches change after each type of interpretive presentation by evaluating (1) change in empathy towards cockroaches, (2) change in attitude towards cockroaches, and (3) change in biological knowledge of cockroaches. While empathy itself was not directly measured in this study, changes in affective language were used as a proximal indicator of empathy-related perception.

2 | Materials and Methods

2.1 | Subjects

For this study, we focused on children participating in an educational summer camp program at the Oklahoma City Zoo and Botanical Garden, Oklahoma City, Oklahoma, USA. Children have served as research subjects in several studies investigating attitudes and empathy towards animals (Kellert 1984; Daly and Morton 2006; Breuer et al. 2015; Schlegel et al. 2015). During the 2024 summer camp season, which lasted ten weeks, twelve camp cohorts were randomly assigned one of two treatments (either the empathetic or ecological presentation). Each treatment took approximately 24 min. to complete (7 min. pre-concept map creation, 10 min. presentation, and 7 min. post-concept map update). Each cohort consisted of 15 students. New cohorts participated each week. A total of 180 campers participated in the study (90 students per treatment). Campers ranged in age from 7 to 12 years old. No identifying information was collected from the children during the study, and all responses were recorded anonymously by the educator. As such, this study was determined to be exempt from the requirements of human subjects research per 45 CFR 46.104(d)(2) by Lincoln Park Zoo Institutional Review Board (IRB-24-001-E).

2.2 | Pre-Presentation Personal Meaning of Insects Map

A modified Personal Meaning of Insects Map (PMIM) was used to evaluate changes in children's perceptions of cockroaches after an interpretive educational presentation (Lemelin et al. 2016; Lemelin et al. 2017). A PMIM evaluation approach is useful as it highlights nuances and inconsistencies that better reflect human nature than dichotomous Likert scales (Lemelin et al. 2016). In addition to documenting conceptual knowledge, PMIM and broader personal meaning mapping approaches are well-suited for capturing affective and attitudinal dimensions of learning, including participants' personal meanings, emotional responses, and motivations related to a topic (Falk et al. 1998; Falk and Dierking 2000; Lemelin et al. 2016). Furthermore, personal meaning maps (PMM) are consistently used in education as an evaluation technique (Eppler 2006; Kalof et al. 2011; Wheeldon and Faubert 2009; Lemelin et al. 2016) to measure knowledge gained. Before each presentation, an educator wrote the word 'cockroach' on a dry-erase board in black ink. Children were then prompted to say as many words and phrases as needed to reflect their thoughts, ideas, and feelings about cockroaches (Lemelin et al. 2017). Each child was invited to contribute, and those who chose to participate had their responses added to the board by the educator, using blue ink to build a simplified concept map (Figure 1). Repeated responses were emphasized using circling, underlining, or tally marks to indicate frequency. To protect the anonymity of participating children, responses were recorded at the group level. A photo of the complete pre-presentation concept map was taken before the interpretative presentation.

2.3 | Interpretative Presentation

After the completion of the pre-presentation concept map, children were presented with one of two 3-min scripted pre-recorded interpretative presentations with cockroaches. One presentation highlighted the ecology, social structure, and importance of cockroaches from a strictly factual and biological perspective, whereas the other presentation highlighted the same information but with a focus on presenting the information in an empathic manner which included giving the cockroaches names and other anthropomorphic characteristics (e.g., families, being a mother, boys competing for girls; see video scripts in the supplementary file). The video footage was identical, showing a male and female educator holding and interacting with cockroaches. The voiceover featured either the ecology or empathy script split evenly between the two educators. After the video, three live cockroaches (one female, two males) were brought into the classroom to give the children the opportunity to interact with the insects for approximately 7 min. No additional information was provided by the educator. At the conclusion of the 7 min the cockroaches were taken out of the classroom, concluding the interpretive presentation.

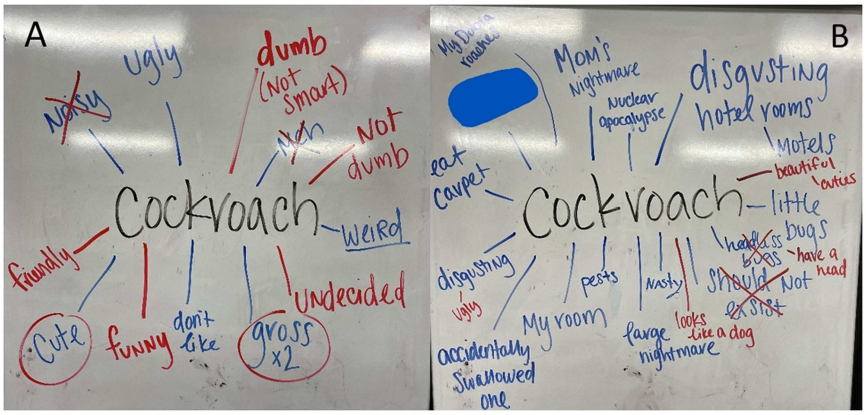

FIGURE 1 | Completed post-presentation personal meaning of insect maps (PMIMs). Cockroach, written in black, was the starting word for each map. Words/phrases in blue were written pre-presentation, and words/phrases in red were written post-presentation. (A) PMIM after an interpretive ecology presentation and (B) PMIM after an interpretative empathy presentation. To avoid any potential negative associations with brands, a home-sharing company name has been obscured in the presented material. [Color figure can be viewed at wileyonlinelibrary.com]

2.4 | Post-Presentation Personal Meaning of Insects Map

After the presentation concluded, the children were encouraged to reflect and make adjustments to the pre-presentation concept map. Any new words, phrases, or changes were written by the educator in red ink. Similar to the initial mapping activity, each child was invited to participate, and repeated responses were emphasized using circling, underlining, or tally marks. If children disagreed with a word or idea, this was also indicated on the map by labeling it with a contrasting term (e.g., "smart" vs. "not-smart"). After completion of the post-presentation concept map, a second photo was taken to be used for comparison to the initial photo of the pre-presentation concept map.

2.5 | Analysis

All pre- and post-presentation concept map images were transcribed into Microsoft Excel. During transcription, both single words (*e.g.*, cool, little) and multi-word phrases (*e.g.*, accidentally swallowed one, my Dubia roaches) were counted as single units. Phrases were not broken down into individual words. Only words and phrases that remained visible (i.e., not crossed out) in the post-presentation concept map were included in the final word count. Additionally, any words/phrases that were circled or underlined on post-presentation maps received additional counts to reflect their emphasized importance. In the case of tally marks, the word or phrase was counted once for each mark. A content analysis approach was used to identify common themes, attitudes, and ideas about cockroaches (Lemelin et al. 2016; Geest et al. 2024).

Three distinct coding frameworks were used to analyze the data: (1) empathy associations, (2) Kellert's attitudinal categories, and (3) biological accuracy. To measure empathy, data reviewers determined and agreed upon a positive (*e.g.*, cool, interesting), neutral (*e.g.*, little, mites), or negative (*e.g.*, disgusting, nightmare) empathy association for all words/phrases (Lemelin et al. 2016). Creating positive and negative empathy word association lists allows shifts in participants' empathy to be tracked (Lemelin et al. 2016). Words/phrases were further sorted into categories based on Kellert's nine attitudinal scales to measure participants' attitudinal shifts (Kellert 1984). Naturalistic words/phrases were those associated with affection for cockroaches, wildlife, or the outdoors (*e.g.*, love, friendly, cute, amazing). Ecologistic words/phrases were those associated with interrelationships between cockroaches and other species (*e.g.*, mites, prey, big to ants) or cockroaches and their natural habitats (*e.g.*, poop = fertilizer). Humanistic words/phrases were those associated with animals as pets (*e.g.*, my Dubia roaches, pets). Scientific words/phrases were those associated with the physical attributes of cockroaches (*e.g.*, little, visually brown, have a head) or the biological functioning of animals (*e.g.*, poop = fertilizer). Utilitarianistic words/phrases were those that associated cockroaches with economics or profit (*e.g.*, rich, coins). Negativistic word association is identical to negative empathy word association, and thus, no additional categorization was needed. There were no words associated with the remaining three Kellert attitudinal categories: moralistic, aesthetic, or dominionistic, and as such, those categories were not used. Lastly, biological words/phrases were sorted and tallied based on accuracy.

All words/phrases were independently sorted into categories by three evaluators: one study author (EAG) and two educators (HH, KC). Words/phrases could be sorted into multiple categories (*e.g.*, poop = fertilizer was placed in both the ecologistic and scientistic categories) (Geest et al. 2024). The evaluators then collaboratively reviewed their categorizations and used a consensus-based approach to resolve disagreements. Although evaluators were not blind to treatment assignments, disagreements were resolved through independent comparison and consensus, which helped minimize potential bias. This strategy was selected due to the short-format and categorical nature of the responses and ensured consistency across empathy, attitudinal, and biological categorization. Because the data consisted of categorical word counts collected anonymously at the group level, Chi-square tests of homogeneity were used to compare distributions of empathy, attitude, and biological knowledge categories before and after the presentations (Franke et al. 2012). All statistical analyses were conducted in *R*, and Cramer's *V* was calculated to estimate effect sizes for significant chi-square results. Bonferroni-corrected post-hoc tests were applied for chi-square analyses involving more than two categories using the *chi-square. posthoc* package (R Core Team 2024)."

It is important to note that although words and phrases were used as the unit of analysis, these were generated collaboratively on 12 group-level maps (one per camp cohort). This group-based structure introduces the potential of clustering, as individual children's contributions may have been influenced by their peers. While this limits the independence of individual data points, it is appropriate for the exploratory goals of the study and allowed for the capture of group-level shifts in empathy, attitude, and knowledge framing (Macia 2015; Conceição et al. 2017).

3 | Results

A total of 332 words/phrases was recorded from 12 camp sessions (6 empathy treatments yielded 173 words/phrases and 6 ecology treatments yielded 159 words/phrases), with 180 (7–12 yrs) participants (~ 90 children per treatment, 6 cohorts per treatment). The most common words associated with cockroaches before treatments were disgusting ($n = 11$), gross ($n = 10$), and ugly ($n = 6$). After the ecology presentation, the most common words were: cool ($n = 5$), cute ($n = 5$), gross ($n = 5$), and pet ($n = 5$). After the empathy presentation the words were more diverse with fewer repetitions; the most common words were: gross ($n = 4$), beautiful ($n = 2$), cool ($n = 2$), cute ($n = 2$), hiss ($n = 2$), pest ($n = 2$), ugly ($n = 2$), and weird ($n = 2$).

The word cockroach had fewer negative word/phrase associations after both the ecology presentation (χ^2 (2, $N = 159$) = 7.35, $p = 0.03$, Cramer's $V = 0.15$, Bonferroni post-hoc: $p < 0.10$; Table 1) and the empathy presentation (χ^2 (2, $N = 173$) =21.52, $p < 0.01$, Cramer's $V = 0.25$, Bonferroni post-hoc: $p < 0.01$; Table 1). Positive word/phrase associations significantly increased after the empathy presentation (χ^2 (2, $N = 173$) = 21.52, $p < 0.01$, Cramer's $V = 0.25$, Bonferroni post-hoc: $p < 0.01$; Table 1), but did not change significantly after the ecology presentation (χ^2 (2, $N = 159$) = 7.35, $p = 0.03$, Bonferroni post-hoc: $p = 0.49$; Table 1). Total neutral word/phrase associations did not change significantly after both the ecology (χ^2 (2, $N = 159$) = 7.35, $p = 0.03$, Bonferroni post-hoc: $p > 0.10$) and empathy presentations (χ^2 (2, $N = 159$) = 7.35, $p = 0.03$, Bonferroni post-hoc:

TABLE 1 | Summary of word/phrase association outcomes by presentation type (ecology script or empathy script).

Category	Word association	Word/multi-part phrase example	Ecology script	Empathy script
Empathy	Negative	scary, dumb, disgusting	Decreased	Decreased
	Neutral	Madagascar, little, mites	Same	Same
	Positive	cool, cute, interesting	Same	Increased
Scientific Accuracy		eat dead leaves = true rolls into ball = false	Same	Same
Kellert's Attitudinal Scales	Naturalistic association	love, friendly, beautiful, amazing	Same	Increased
	Ecologistic association	poop=fertilizer, prey, mites, big to ants	Same	Same
	Humanistic association	my Dubia roaches, pets	Same	Same
	Scientistic association	little, visually brown, have a head	Same	Same
	Utilitarianistic association	rich, coins	NA	NA

Note: Utilitarianistic had too low a sample size for analysis. Moralistic, aesthetic, and dominionistic attitudinal scales were not present.

$p > 0.10$; Table 1). Total biological word/phrase accuracy remained the same after both the empathy (χ^2 (1, $N = 63$) = 1.39, $p = 0.24$; Table 1) and ecology (χ^2 (1, $N = 52$) = 0.01, $p = 0.98$; Table 1) presentations. Naturalistic associated words/phrases remained the same after the ecology presentation (χ^2 (1, $N = 159$) = 3.04, $p = 0.08$; Table 1) but increased significantly after the empathy presentation (χ^2 (1, $N = 173$) = 14.54, $p < 0.01$, Cramer's $V = 0.29$; Table 1). Ecologistic-associated words/phrases remained the same after both the ecology presentation (χ^2 (1, $N = 159$) = 1.16, $p = 0.28$; Table 1) and empathy presentation (χ^2 (1, $N = 173$) = 1.67, $p = 0.20$; Table 1). Humanistic associated words/phrases remained the same after the ecology ($\chi 2$ (1, $N = 159$) = 0.61, $p = 0.43$; Table 1) and empathy ($\chi 2$ (1, $N = 173$) = 1.08, $p = 0.30$; Table 1) presentations. Scientistic associated words remained the same after the ecology (χ^2 (1, $N = 159$) = 0.29, $p = 0.59$; Table 1) and empathy (χ^2 (1, $N = 173$) = 0.31, $p = 0.58$; Table 1) presentations. Only four words/phrases in total were categorized as utilitarianistic, and thus, the sample size was too small to use statistical analysis.

4 | Discussion

To determine if interpretive presentation style impacts children's personal meanings (empathy, attitude, and knowledge) towards cockroaches, we had children create PMIM maps before and after ecological and empathetic presentations. The word cockroach had fewer negative word/phrase associations in PMIMs after both the ecology presentation and the empathy presentation, suggesting that either style of presentation is effective in reducing children's negativity towards a disliked animal. This is not surprising, as knowledge about an animal can enhance understanding of its value (Hills 1995; Myers 2007; Owen and Aquarium 2015) and also increase relatability to that animal (Myers 2007; Owen and Aquarium 2015). This would presumably also lower overall negativity towards that animal. Most notably, positive words and phrases associated with cockroaches only increased after the empathetic presentation. Specifically, words/phrases categorized as naturalistic according to Kellert's attitudinal scale, which are those associated with affection (e.g., love, friendly, cute, amazing), increased significantly after the empathetic presentation, but not after the ecological presentation. Presentation style did not result in significant differences for any of the other Kellert attitudinal scale categories we used (i.e., ecologistic, humanistic, and scientistic).

Empathy towards wildlife comprises the construct of emotional affinity towards nature (Kals et al. 1999; Owen and Aquarium 2015), which includes positive feelings towards wildlife and nature (Kals et al. 1999). Thus, it follows that naturalistic words/phrases indicative of affection for animals would increase after an empathetic presentation. Our study provides evidence that using an empathetic presentation style can reduce negativity, increase positivity, and increase affection towards cockroaches. Although empathetic interpretation is increasingly recommended as a strategy for promoting pro-environmental behavior (Chawla 2009; Young et al. 2018), there remains a significant research gap due to the lack of applied studies. Our study addresses this gap by being the first to empirically demonstrate that empathetic interpretation can enhance positive perceptions of a typically disliked taxon.

Fostering positive perception of and affection toward an insect that tends to be disliked increases connection with that animal/species, and provides an opportunity to amplify conservation awareness and inspire people to engage in behaviors that support insect conservation. This is especially important given the global decline in most insect populations and the foundational role insects have across ecosystems (Malt* and Marsh 2023). Global insect experts identified education as an important conservation measure, and some said its conservation value was second only to land management and protection (Miličić et al. 2021). Similarly, Basset and Lamarre (2019) recognized the need to change the public's negative perceptions of most insects and urged using biological education and citizen science to promote empathy and curiosity towards insects. Our findings indicate that education using an empathetic approach is more effective in increasing caring than providing ecological/biological knowledge alone. This is unsurprising, as facts alone rarely change minds; instead, incorporating emotions and values are necessary components to improve conservation communication (Toomey 2023). To improve insect education programs, incorporating empathetic presentation strategies may shift public

perception of disliked insects, encouraging conservation-friendly behavior. However, further research is needed to assess whether these approaches instill behavioral changes that support insect conservation efforts.

A concern with empathetic presentations is the use of strategic anthropomorphism, particularly when it involves human-like analogies that are not grounded in accurate biological information. Anthropomorphism is continually happening (Owen and Aquarium 2015), especially among young children (Myers 2007; Chawla 2009; Owen and Aquarium 2015) and comes with risks of misunderstanding and inaccuracy (Hills 1995; Myers 2007; Root-Bernstein et al. 2013). However, recent research highlights its potential value as a conservation and interpretive tool when used thoughtfully. Anthropomorphic framing can increase emotional engagement, improve attention, and strengthen pro-environmental attitudes (Chan 2012, Whitley et al. 2021). Williams et al. (2021) further demonstrate that anthropomorphism of nature is positively associated with a range of pro-environmental variables, including connectedness to nature, concern for wildlife, and conservation-oriented behavior. These findings provide theoretical support for why empathetic framing may be particularly effective for shifting children's perceptions of disliked taxa when paired with accurate biological information. Thus, using tailored and structured anthropomorphism grounded in accurate biological information is recommended to reduce misunderstandings about animals (Myers 2007; Chawla 2009; Owen and Aquarium 2015). Otherwise, presenting animals solely in biological terms, without any anthropomorphism, may result in them being valued only for their biological function (Myers 2007). Interestingly, in our study, we found no significant differences in biological accuracy between pre and post-PMIM according to the style of presentation. This provides evidence that the use of strategic anthropomorphism did not increase biological inaccuracy, nor did framing the presentation in ecological terms result in increased focus on biological function. Similarly, neutral, ecologistic, humanistic, and scientistic words/phrases remained the same between pre and post PMIM for both styles of presentation.

Further research is needed to determine if the educational presentation style affects children's perceptions towards other negatively viewed arthropods, especially wasps and spiders, which may elicit more fear or avoidance than do cockroaches (Riskind et al. 1995, Knight 2008; Lemelin et al. 2015; Sumner et al. 2018). Research is also needed to determine the impacts of interpretative presentation style on knowledge, attitudes, and feelings towards other generally disliked vertebrate taxa, including snakes (Davey 1994; Polák et al. 2016), amphibians (Ceríaco 2012; Tarrant et al. 2016), rodents (Makundi et al. 2005), and bats (Boso et al. 2021), all of which are taxa in need of conservation efforts.

It is important to note that the children in this study were enrolled in an animal-themed camp at a zoo, and thus were likely more interested in animals and nature than children randomly selected from the general population. Thus, our results might not be generalizable across children whose interests may be more varied. Another limitation is that the children's intended meanings could have been misinterpreted by the educator who collected the responses anonymously in a group setting. For example, while only four words had utilitarianistic connections (rich, coin, coin, coins), it is unknown if these words were associated with cockroaches due solely to economic connections or if they were being used as a size comparison (*i.e.*, cockroaches are the same size as coins). There is both a meme cryptocurrency/altcoin named after cockroaches called Cockroach Coin or Roach Coin (finance. yahoo. com), as well as numerous online stock images that show cockroaches placed next to coins for size comparisons (www.shutterstock.com). Maintaining the children's anonymity was an appropriate aspect of our research design, but it did prevent us from following up with children to understand their exact intended meaning for some of their responses or to evaluate whether observed changes persisted over time. Additionally, since all responses were recorded at the group level, peer input may have influenced individual contributions. As such, words/phrases were not fully independent, and this collaborative group-level context should be kept in mind when interpreting the results. Finally, the study focused on a single insect species, and additional work with other arthropods would help determine the extent to which these patterns generalize.

Overall, the style of interpretative presentation can positively influence attitudes and empathy towards cockroaches. By adopting an empathetic approach in educational presentations, a more meaningful impact can be achieved, resulting in reduced negative perceptions, increased positive attitudes, and stronger naturalistic associations towards cockroaches. This approach can be more effective than biology-focused education alone, as it engages both the emotional and cognitive dimensions of learning, encouraging greater care and conservation behaviors. However, more work is needed to determine if these patterns hold across age groups, audiences with different interests, or for other taxa. Future research should also assess the retention of these positive affective changes over time to determine whether empathetic interpretation produces lasting shifts in children's attitudes toward insects.

Author Contributions

All authors contributed to the methodology. Authors E. A. Geest and R. J. Snyder contributed to conceptualization and data collection. E. L. Webb contributed to data curation, visualization, and materials preparation. E. A. Geest performed the data analysis and wrote the first draft of the manuscript. All authors commented on previous versions of the manuscript. All authors read and approved the final manuscript. The geographical distribution of the authorship team broadly represents the major region of interest in the study.

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The authors have nothing to report.

Ethics Statement

Animal Research: The authors have nothing to report. Human Research: This study was determined to be exempt from the requirements of

human subjects' research per 45 CFR 46.104(d)(2) by Lincoln Park Zoo Institutional Review Board (IRB-24-001-E).

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

Data are provided as supplementary files.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section.
SupplementaryFile_Data.