Effects of Self-Guided Displays and Associated Interactive Elements on Visitor Knowledge, Attitudes, and Values

By

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ABSTRACT

Free-choice learning environments provide visitors with unique opportunities to observe and learn voluntarily and can serve as valuable educational opportunities. Incorporating interactive elements into displays have been shown to increase visitor dwell time and, ultimately, enhance the displays' impacts on visitor knowledge and positive attitudes. This is especially important in free-choice learning environments where the visitor controls what display to visit and for how long. Visitors may not benefit from the display if they are not engaged with some attention-holding component. Interactive elements can greatly benefit a display's potential to strengthen a visitor's conservation attitudes and values of non-charismatic species that are traditionally less engaging due to their lack of activity or their appearance. This study examined the effect of a self-guided display with or without the incorporation of interactive elements on a visitors knowledge, attitude, and value of rattlesnakes. In Spring 2019, university biology students took surveys before (pre-survey) and after (post-survey) visiting a live animal rattlesnake display on campus. This was repeated in the Fall 2019 except that eight interactive elements were incorporated into the rattlesnakes displays. The pre and post-surveys were designed to evaluate the effect of the displays on student knowledge, attitudes, and values towards rattlesnakes. Paired t-tests revealed that visiting the displays increased student knowledge, attitude, and value of rattlesnakes, but that this effect was not enhanced by adding the interactive elements to the display. The results also showed that visiting the displays increased visitor dwell time, positively influenced one's interest in revisiting the displays, and, overall provided visitors with enjoyment. These results provide further evidence that self-guided, live animal displays are impactful on increasing visitor knowledge, attitude, and value. However, the results also demonstrate that interactive elements do not necessarily enhance a display's value, so further research should be conducted to determine key traits of effective interactive elements. This data and that from future related studies can have powerful conservation implications by informing on how displays can be optimized to achieve desired objectives.

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INTRODUCTION

The inclusion of educational components to public displays at zoological facilities, aquariums, museums, science centers, and conservation centers provides valuable learning opportunities in hopes of advancing knowledge, interest, and participation in various activities including conservation efforts (Falk, 2010). Displays, while varied, all focus on individual themes, and each tells its own story of an item, place, part of history, person, or animal. These facilities help bridge gaps in knowledge and provide people an opportunity to learn about a wide array of issues; they are unique by being some of the only places that interpret and educate on specific cultural, social, and environmental topics (Tunnicliffe, 1997; Rennie, 2006; Schwan, 2014). Each facility has a specific focus but collectively museums and like institutions develop environments that have a broad but immense educational impact on their visitors, such as skill development, historical engagement, preserving culture, and conservation action (Falk, 2010).

Specific interpretive components are required in order for visitors to create and make meaning of any display that they encounter. First hand experiences with objects or animals can lead to heightened visitor engagement by increasing time spent at exhibits and knowledge (Jeffery, 2006; Fernandez, 2009). These experiences are even more impactful when paired with an exhibit interpreter to help guide the experience (Swanagan, 2000; Powell, 2014). While in-person interactions or tours are useful components of visitor learning and have been supported to help heighten visitor engagement, it is not available in every setting. There are significant labor demands to having an in person docent or staff member at each exhibit and some exhibits get priority over others that could result in unequal learning outcomes. Typically, content is accessed via self-guided tours, meaning visits to any particular display and the extent to which any educational components are utilized is completely voluntary. Museums, and like institutions, are clear settings where free-choice learning occurs.

Free-choice learning environments can greatly benefit from displays having interactive components. “Free-choice learning” describes learning environments that are non-sequential, self-paced, and voluntary (Falk, 2001). While there is great potential to learn in such environments, visitors must become engaged with the displays and the learning opportunities the exhibits provide on their own (Hein, 1998). Because an individual display and its subjects can vary, there can be differences in how visitors interact with these displays and thus on the varied learning outcomes based on display uniqueness (Koran, 1983; Sandifer, 2003). In these educational settings, it is critical for the success of the educational process to understand what the learner does or does not know (Tunnicliffe, 1997). Like K-12 and postsecondary classrooms, there is variation in learner's background knowledge (Inkelas et al., 2008) which can consequently affect individual learning experiences. As such, it's important to consider the prior knowledge of visitors when designing displays. Furthermore, when constructing learning experiences it's important to provide a variety of learning activities to maximize accessibility to all visitors. Thus to maximize learning, it is essential to provide visitors a diverse set of informative displays that are constructed in a way that acknowledges visitors prior background knowledge and uses a variety of interactive elements and objects (Schwan, 2014).

Attention driving devices are defined by specific characteristics that an interactive element has that can include technological novelty, ability to stimulate a sense, or ability to be user-centered (Sandifer, 2003). These devices allow for interactivity and can focus learning to one theme, impacting the process of learning in a positive manner (Koran, 1983; Sandifer, 2003). Interactive exhibits that have been shown to hold a guest's attention for longer durations result in a guest acquiring more knowledge, correcting misconceptions, and situating newly acquired knowledge within pre-existing frameworks (Koran, 1983; Swanagan, 2000). Improving knowledge provides visitors with positive takeaways from their visit thus helping to create a more memorable experience (Swanagan, 2000). Greater knowledge has also been assumed to additionally have positive effects on attitudes, as the more someone knows about a subject, the more likely they are to devote time or interest to it (Screven, 1986). Exhibits that influence visitor attitude also contribute to creating a positive visitor experience, which that can lead to higher levels of engagement within a visit or potential conservation action that continues the interest after the visit (Schwan, 2014; Swanagan, 2000). While there is limited research on the effects of knowledge on attitude, research that is available suggests that learning opportunities that increase knowledge are critical to promoting a change in attitude over time (Bruskotter, 2007).

For exhibits that include animals, the ability to draw visitors' attention and thus the overall educational value of the exhibit may be limited depending on the visibility and activity of the animal. Many live-animal exhibits have signage to help educate, but visitors often have limited interest in reading text without subsequent interactive elements to aide in the learning process (Verbeke et al., 2001). Therefore, displays may benefit from additional educational components that are more enticing to the visitor. Having touch experiences and interpretive materials, such as a skull or animal call sound box, paired with live animal displays have been shown to foster an effective learning experience, such as increased knowledge and attitude towards the animal (Tunnicliffe, 1997; Lindemann-Matthies, 2006). Positive emotional experiences of visitors can interact with knowledge of and affinity for nature to promote conservation awareness, value towards a specific topic or animal, and an increase in learning (Swanagan, 2000). However, the significance of the emotional response of the visitor is, in part, due to the species being observed (Powell, 2014).

Aesthetics, in general, are an important determinant of people's perceptions of species, specifically those species that are endangered (Knight, 2007). Many of the aforementioned studies were conducted on charismatic large mammals in the presence of employees who would provide interpretation, so it is unknown whether the inclusion of interactive components to self-guided animal displays, especially those containing non-charismatic animals such as a snake, an insect, or a fish, are effective at increasing the educational value of a display. Those species that are more engaging, charismatic, and aesthetically pleasing have been shown to elicit a more positive emotional response in a visitor (Kellert, 1980; Knight, 2008), thus there is a limited understanding about what strategies are needed to elicit a positive emotional response in a visitor when viewing a less charismatics animal with which visitors traditionally hold negative perceptions of.

Overall, educational animal displays focus on communicating concepts about the individual species, but there is little known about how effective, if at all, displays are at furthering intellectual developments such as learning and idea creation, or at impacting thought and action. Up-close animal experiences, specifically eye-to-eye encounters, without interactive elements, affected positive emotional experiences including positive attitudes and values towards the animal being observed (Powell, 2014). Alternatively, some studies have shown that interpretive programs such as a public presentation or talk have increased knowledge but had no effect on attitude (Ham, 2007), but this affect was not specific to a display topic. The subject of the display and the preconceived attitude that visitors have towards it may influence how displays are perceived and the value of incorporating interactive components. Conceivably, it might be more challenging to induce visitor engagement, and thus effectively achieve learning objectives, for displays portraying a species that often evokes a negative reaction such as non-charismatic species. Thus, there is great need for studies on how an interactive or interpretive element influences interest in a negatively perceived species such as a reptile, an amphibian, or an invertebrate and the viewers attitude or value of that subject. This need is heightened for local native species where a visitors knowledge, attitude, and values can directly impact species conservation nearby and be much more meaningful.

Rattlesnake displays were chosen for the focus of this study because of the study site available but also because of the negative perceptions of them. Snakes have been a symbol for evil and poor personality traits for decades in religion and folklore among many different cultures and are perceived broadly to be aggressive, leading people to have significant preconceived fears (Whittaker, 2000; Pinheiro, 2016). Snakes, in general, are valued lower aesthetically and have induced fear broadly among populations because of potentially dangerous traits seen in a few snake species (Kellert, 1980; Knight, 2008; Pinheiro, 2016). In a location such a Phoenix, Arizona, where rattlesnake species are prevalent, educating the public and learning effective ways of broadening perspective in hopes of eliminating the publics' fears of snakes is essential.

The purpose of this study is to evaluate the effect of adding interactive components to self-guided rattlesnake displays on visitor knowledge, attitude, and value. Accordingly, I hypothesized that:

H1: controlled viewing of displays housing negatively perceived animals will induce positive learning, attitude, and value outcomes regarding those animals.

H2: adding interactive elements to displays housing negatively perceived animals further enhances the effect of controlled viewing of said animals on visitor knowledge, attitude, and value as compared to displays lacking interactive elements.

H3: adding interactive elements to displays housing negatively perceived animals will increase time spent at an exhibit and interest in repeated visitation as well as improve visit enjoyment.

First, I predicted that viewing rattlesnakes up close will increase one's knowledge, attitudes, and value pertaining to rattlesnakes. Second, I predicted that including interactive elements to rattlesnake displays will provide increased knowledge, attitude, and value benefits to visitors as compared to displays lacking these elements. Third, I predicted that survey responses relating to time spent, number of times revisiting an exhibit, or visitation enjoyment would be higher in surveys after interactive elements were added to displays as compared to surveys given out prior to visitors who viewed displays lacking interactive elements. These benefits could help to create positive interest in rattlesnakes and foster support for conservation of rattlesnakes. To address these predictions, we used pre- and post-visit surveys to evaluate how visitors' knowledge, attitude, and values were affected by visiting animal displays that either lacked interactive elements beyond basic signage or that incorporated interactive elements, such as touch boards, light boards, interactive food webs, wheels, and reveal boxes.

LITERATURE REVIEW

Visitor Learning in Educational Facilities

Much of the research on visitor learning has been conducted by Falk and Dierking (2004, 2010). Visitor learning has been investigated under a broad array of contexts, including art exhibits, natural history facilities, science centers, zoos, aquariums, botanical gardens, nature centers, and historic sites, collectively referred to as “museums.” Free-choice learning is defined as being “non-linear, personally motivated, and involves considerable choice on the part of the learner on what to learn and where to participate in learning” (Falk & Dierking, 2000). Free-choice learning is argued by Falk and Dierking to be the primary source of how most people learn and what people find to be a valuable experience (Falk & Dierking, 2000). Free-choice learning goes beyond simply acquiring facts or understanding concepts, but also provides a rich and emotional experience by connecting social, cultural, environmental, and historical meaning with visitors (Falk & Dierking, 2000). Consequently, free-choice learning experiences are important for educational facilities to incorporate into their displays and programming. However, free-choice learning experiences in museum settings are still being evaluated in terms of how they impact visitor learning and how they influence visitor’s ability to apply gained knowledge to their lives (Falk & Dierking, 2000; Falk et al., 2003). One aspect of visitor learning in free-choice settings that has been documented is that learning in these settings is complex due to variation in the visitors themselves, causing challenges in measuring data for varied experiences (Falk et al., 2003). Future research relating to free-choice learning experiences would benefit from more thoroughly examining how effective visitors are at finding meaning in, making connections from, and learning from varied museum settings.

Challenges and Benefits of Self-guided Displays

There has been a lack of understanding regarding the importance of exhibition design on intellectual gains made by visitors; museums have been pushing towards a more visitor-centered approach that focuses on how visitors are learning and how they interact with guided- and independently viewed displays (Falk & Dierking, 2000; Charitonos, 2012). Guided tours or other interpretive experiences can be beneficial for some types of learners; however, the average visitor typically interacts with the surroundings independent of a guided tour or audio guide. Thus, there is interest in what kinds of exhibits draw visitor's attention and what display characteristics lead to effective learning experiences (Moser, 2010). The more traditional way of learning in a museum is without the presence of an interpreter, allowing for a personalized learning experience that helps guests to retain knowledge based off of individualized interest and leave with a more memorable self-driven experience (Hein, 1998).

One challenge of self-guided displays is the current lack of understanding regarding how one intentionally or unintentionally learns from an exhibit. Because there is so much variation in visitor demographics among and within institutions, an approach that is successful in one institution may not be successful in another. How much visitors learn and how much prior knowledge they have also varies among visitors, making it essential for self-guided exhibits to address the varied needs and goals of a diverse audience (Falk, 2010). Every institution is unique in their own goals and in what their learning outcomes are for visitors. Some institutions even have several goals and outcomes depending on each individual exhibition. When goals are not clearly defined or encompass more than one idea, it can be challenging to identify a given learning outcome or identify learning gains (Falk, 2010). While visitors may not be learning every specific goal set in place by an institution, it is clear that learning is happening and visitors are increasing their knowledge even if it was not intended (Boisvert & Slez, 1995; Falk & Dierking, 2000; Falk et al., 2003).

Additionally, there are also challenges in understanding how visitors use different spaces. The variation of visitors leads them to spending unequal time in galleries, sometimes even completely bypassing a gallery. This variation also impacts visitor attention and what will ultimately draw the visitor to a given space. Visitor attention is complex but is roughly defined by psychological and physiological processes that capture, focus, and engage an individual based on personal, perceptual, and environmental factors (Bitgood, 2016). While there are clear challenges to creating successful self-guided displays, education and entertainment are necessary for promoting interest, furthering knowledge, and influencing audiences (Boren, 1997; Hein, 1998; Fernandez, 2009; Mann-Lang, 2016). Recognition of this value is evident in the rise in investments into renovating exhibits to provide an enhanced, more engaging experience for visitors to self-guided exhibits (Bitgood, 2016).

Interactive Elements

Rechargers (those coming to find relief or revival), explorers, facilitators, professionals, and experience seekers each come to an educational facility with their own agenda (Falk, 2006). Each has their own needs and individualized goals when visiting. While the primary objective of some may be to acquire knowledge, visitors more commonly focus on recreation, entertainment, socializing, and aesthetic appreciation (Schwan, 2014). Therefore, it is necessary to draw visitors into learning. As learning is a sensory experience, educational efforts are most effective when they use multi-sensory deliveries that are accessible to all visitors (Jeffery et al., 1996; Falk, 2006).

Exhibits that include interactive elements have been shown to be more attractive to museum visitors (Sandifer, 2003). Research has also shown that interactive exhibits have higher holding power, or ability to hold a visitors attention, than non-interactive exhibits (Koran & Koran, 1983; McKenna-Cress & Kamien, 2013) An interactive element can include technological components, sensory experiences, moving or stationary objects, and in-person presentations or tours. Interactive elements are components of exhibits that require visitors to perform an action beyond just observing an exhibit. Physical immersion with an object can result in a visitor feeling more connected and satisfied with their experience, ultimately leading to a more memorable experience as opposed to simple observation (Screven, 1986). However, just because something may be memorable does not mean that it is educational. Thus, it has been shown that the interactive elements of a display need to be closely linked to the knowledge trying to be conveyed in order to increase learning (Jeffery et al., 1996).

There are numerous examples of interactive elements being successful but some follow specific guidelines or principles. Research on an art exhibit demonstrated success in promoting learning by reducing visitor options, using familiar materials that are recognizable, and using clear constraints that allow a sense of direction on how to interact and learn (Pitts, 2018). Due to varied learning outcomes among museums, success has typically been measured in research studies on exhibits using a "Generic Learning Outcome" or GLO, co-developed by the University of Leicester, that can include multiple factors as a measure for success including; knowledge, understanding, skills, activity, behavior, progression, attitudes, value, enjoyment, inspiration, or creativity (Pitts, 2018). Many of these interactive components focus on fun and entertainment as key indicators of learning and engagement in a free-choice setting, as these indicators have been shown to be the most effective at promoting positive visit experience but vary across museum settings and topics (Van Winkle, 2014).

Knowledge, Attitude, and Value Influencing Conservation

In addition to providing the visitors with knowledge, it is also critical for educational displays to influence the visitor's attitudes and values regarding the display topic. This is especially important in the scope of conservation. An individual's response to their environment is based on three domains: affect (attitudes), cognition (knowledge), and behavior (choices based on values) (Iozzi, 1989). Knowledge is defined and measured as an accumulation of an individual's known facts on a subject separated from beliefs or feelings towards the subject. Attitudes reflect an individual's positive or negative perceptions towards the subject, whereas values are deeper developments surrounding larger ideas on how an individual may view and think about a subject (Iozzi, 1989).

Previous knowledge has been identified as the most important factor influencing a visitor's learning (Ausubel, 1968). Any new learning is ultimately constructed off of prior knowledge and appropriate motivation (Falk & Dierking, 2000). Knowledge and a positive attitude are important for promoting learning, eventually leading visitors to conservation-minded behavioral decisions (Pooley et al., 2000). Zoological facilities that display live animals provide immense value to conservation education because they provide repetitive learning opportunities that increase prior knowledge, support deeper learning, and further understanding by making real world conservation connections (Ausubel, 1968; Falk & Dierking, 1997).

Guided interpretation utilizes in person tour guides, audio guides, or presentations that have been shown to have positive effects on knowledge, attitude, and value towards charismatic species, resulting in the promotion for conservation of certain species and ultimately success in protecting certain species (Falk et al., 2010). However, is it unknown whether self-guided animal displays, especially those of non-charismatic animals, could be equally effective at increasing educational value and, secondarily, the conservation value of the display (Tunnicliffe, 1997; Lindemann-Matthies, 2006).

Animal Displays

Visitor demographics in a zoo varies greatly from that of other educational facility populations because of the specific nature-based motives of visitors. Motives of visitors can include a desire to satisfy curiosity, fulfill the desire for fun or relaxation, or engage in intellectually stimulating experiences (Falk et al,. 2003). Like interactive elements used in other educational facilities, interactive elements incorporated into animal exhibits provide an array of options for visitors to balance out learning with other motives such as entertainment. Combining experiences of live animals with opportunities for up close and even physical interaction with those animals has been shown to promote scientific reasoning, knowledge gain, and conversation among visitors (Kisiel et al., 2012). Even without interactive elements, up-close experiences such as looking animals in the eye has been shown to increase positive visitor experience (Powell, 2014). By having visitors engage with animals from across the globe in a meaningful and personal way, up-close, regardless of interactive features, there is an opportunity for connection that helps to promote visitor interest in species conservation (Swanagan, 2000; Fernandez, 2009). Overall, providing engaging animal exhibits promotes visitation and consequently may increase the number of new memberships purchased, referrals, or return visits, all of which ultimately help generate revenue for increased conservation efforts and research.

Non-Charismatic Species

A non-charismatic species is classified as an animal or group of animals that have been determined to be less aesthetically pleasing, are less active, and perceived by the public as being non-alluring (Ducarme et al., 2013). Inactive animals typically are less interesting to visitors and can result in visitors provoking or interacting with the animal on their own terms, potentially leading to a negative experience for both the visitor and the animal (Fernandez, 2009). Animals with undesirable or potentially harmful traits, such as reptiles, amphibians, or invertebrates, pose significant challenges to visitor learning, perception, and species support (Carr, 2016). In general, aesthetics are an important determinant for species conservation (Knight, 2008). Species that rank low in aesthetics correlate with more negative attitudes toward that species, less knowledge of that species, and lower support for conservation of that species. This is unfortunate because reptiles, amphibians, and invertebrates, all of which rank low aesthetically, are critical to ecosystems and their communities yet comprise some of the most endangered and at-risk groups (Devine, 1996; Sitas et al., 2009). Kellert (1993) states that certain groups of animals are disadvantaged compared to other species because the general public views them with fear, antipathy, and aversion. He goes on to offer numerous explanations for these negative attitudes. People tend to generalize their fears broadly across similar species. This is clearly seen in snakes. People may be afraid of or dislike venomous snakes for valid reasons, but these opinions are often extended to all snakes because of the lack of knowledge and understanding that most snakes are harmless.

Snakes were chosen as a model animal for this study because of the significant negative pre-dispositions stemmed from folklore, religion, and broad societal beliefs held about them; however, folklore specifically has been paired with associating negative values towards these animals (Ceriaco, 2012; Pinheiro, 2016). In general, snakes are valued lower aesthetically and induce fear broadly among people because of potentially dangerous traits seen in a few snake species (Kellert, 1980; Knight, 2008; Pinheiro, 2016). Snakes are also described as more phobia-inducing to people than amphibians or invertebrates because they posed more a of a threat to mammals as compared to amphibians or invertebrates (Ohman, 2003). This has led snake species to benefit disproportionately in conservation support compared to other species that have reduced challenges and are easily promoted due to their positive attributes (Czech et al., 1998). Additionally, when compared to charismatic megafauna, visitors tend to spend less time at exhibits with non-charismatic species (Brackney & McAndrew, 2001). Consequently, the budget for educational content can be a lower priority for zoos (Fountain, 2009). Even amongst charismatic species, it is difficult to promote conservation efforts, so using similar methods with an animal that is not thought of positively can be complicated even if that animal is just as important to conserve.

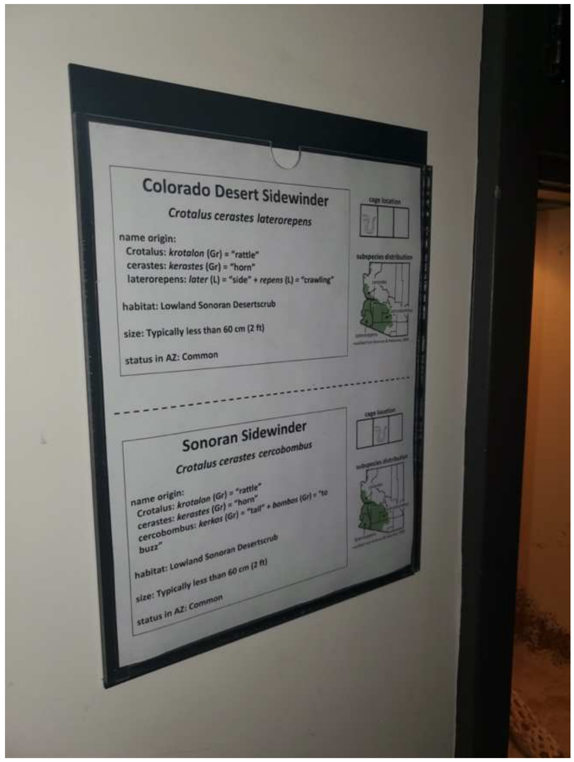
Given the previously demonstrated potential benefit of interactive elements in exhibits, enhancing exhibits of non-charismatic species may be vital to promote general knowledge and conservation of these species. Enhancing snake displays to emphasize the predominance of harmless snakes and even promote the environmental uniqueness and importance of dangerous species can instill knowledge and create positive memories, which might translate into improved attitudes and values related to these animals (Moser, 2010). More broadly, this study aims to focus on creating positive experiences in a free-choice learning setting towards snakes. By enhancing snake displays for visitors rather than providing simple signage, visitors can experience a snake more holistically and in a way that is more entertaining and interesting. Ultimately, this helps to engage otherwise fearful audiences that may never have shown interest in snakes. Zoological facilities are some of the only places that certain non-charismatic species can be seen and interpreted to the public. Thus, zoological facilities are in a unique situation to help bridge the gap between public understanding and reality relating to non-charismatic species. Without displaying these species in an engaging manner, there is very little opportunity for people to learn about these animals, let alone care about conserving of them (Falk et al., 2010; Ansberry, 2018).

METHODS

Study Site

Arizona State University houses numerous departmental museum-esque spaces on each campus. The goal of these areas is to promote various schools and colleges within the university by engaging students and the visiting public. One such space is a live Arizona native reptile display within the main hallway of one of the Life Sciences buildings. “Reptile Row”, as it is commonly referred to (Fig. 1), was chosen as the site for this study for three primary reasons. First, it is accessible to participants. The building is central to campus, being only a 5-10 minute walk from biology classrooms and dormitories, and the building is the home of biology student advising. The building, and thus Reptile Row, is freely accessible on all school days to students but also the general public. Secondly, with the display being part of the University, it was easy to obtain the needed approvals to make temporary alterations to the displays to fulfil the objectives of the study. Lastly, the building is about to go through a partial remodel, and the results of this study will directly influence decisions regarding upgrades to Reptile Row. Given that the building houses primarily native species of rattlesnakes, it puts an emphasis on the projects broader goals and focus on promoting local species.

Graphic 1 – A) Display cages in the hallway of a Life Sciences building on the Tempe campus of Arizona State University. B) Simple informative signs, that are the norm for these displays, can be seen to the left or right of each display.



Graphic 1 – C) Signage located next to each display with information on the animal species.

Eight displays in the east to west corridor of Reptile Row were used because the displays, some of which were sub-divided to separately house multiple rattlesnake species, house solely rattlesnakes (Fig. 1A). Each display had a simple paper sign next to it identifying the species and providing some basic rattlesnake facts (Fig. 1C). The display, in this established configuration, was used as the control group. For the treatment group, eight interactive components were distributed among the displays. Traditionally, "control group" is used to distinguish the group that does not undergo any manipulation. However, the participants in this study do experience a treatment per se by visiting the display. The use of "control" in my group designations is as a description of the display rather than the experience of the participants. That is, in my control group the display is unchanged from its normal appearance in our study, while for my treatment group the display has been manipulated to include the interactive elements. Therefore, my use of control and treatment to describe the two groups provides concise identifying terminology for describing the absence or presence of the interactive elements. The interactives components were removed at the conclusion of the study.

Interactive elements

Eight interactive elements were created for the treatment purposes of this study, each relating to a rattlesnake fact that was presented in the existing signage (Fig. 2A-G). The interactives were designed using the seven characteristics that hold attention as defined by The Philadelphia-Camden Informal Science Education Collaborative (Sandifer, 2003; Boran & Dristas, 1997). As a note, collectively the group of interactives used in the treatment group in this study encompassed all seven characteristics; however, individually, the interactives did not fulfill all seven of these requirements due to fabrication limitations. The characteristics are as follows:

Multi-sided- Interactives allow for groups to cluster around interactive

Multi-user- Interactives allow multiple individuals to interact with the interactive at once.

Accessible- Interactives allow comfortable use by people of varying heights, sizes, or disabilities

Multi-outcome- Interactives are complex and develop an array of ideas or knowledge

Multi-modal- Interactives appeal to different kinds of learners with varied levels of knowledge

Readable- Interactive text is arranged in a way that is easily understood

Relevant- Interactives provide some cognitive links to visitors existing knowledge/experience

The interactives used in this study were designed to be accessible to all audiences and the interactives also varied in aesthetic appeal by being different sizes and located differently, in alignment with best practices (Jeffery et al., 1996). Each interactive also had a set of instructions along with it to guide visitors on its use. Interactives included a fact wheel, two light boards, a Velcro food web, two touch boards with different textures, a magnet maze, and fact revealing boxes.

Graphic 2A – “Whose Eye Is It?” This interactive emphasized the fact rattlesnakes do not have eyelids. It consisted of lift and reveal boxes with various reptilian eyes.

Graphic 2B – “Venom or Poison?” This interactive emphasized the fact that rattlesnakes are venomous, not poisonous, by having the visitor choose between these two possibilities for a variety of animals. A red or green light illuminated based on the correctness of the selection.

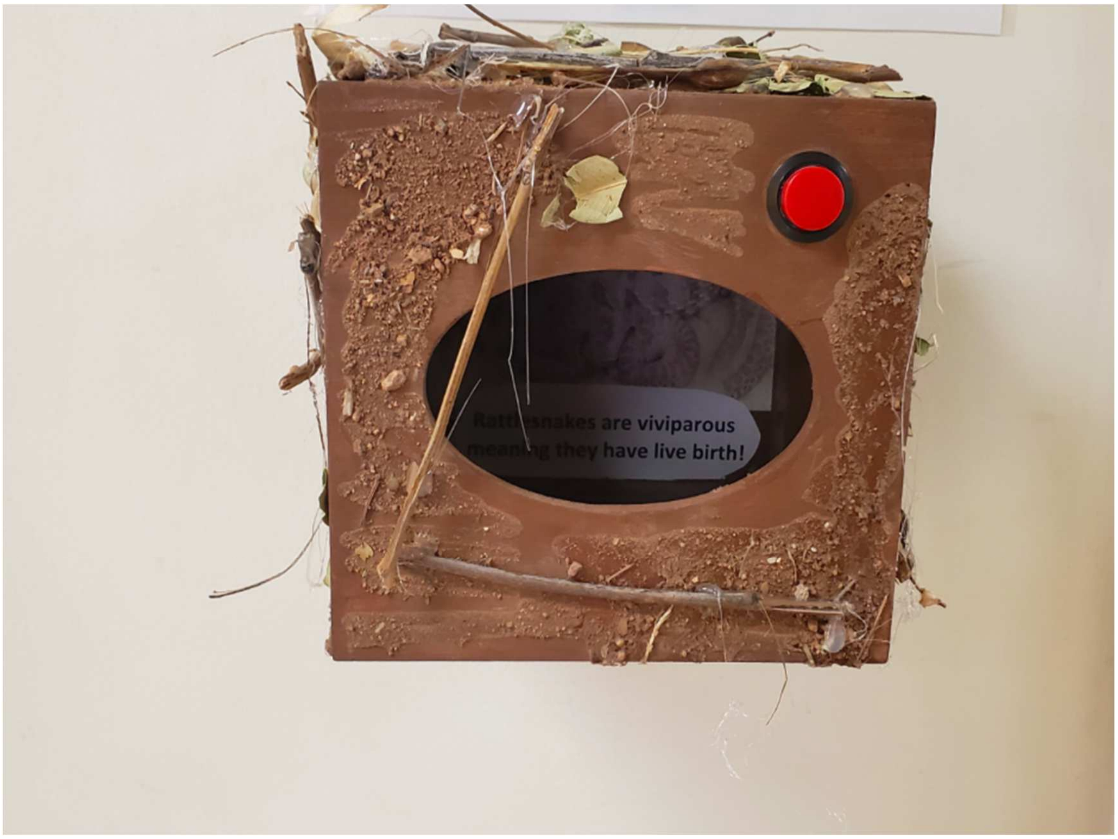
Graphic 2C – "Food Web" This interactive emphasized the fact that rattlesnakes are central in the food web, having numerous predators and prey. This was achieved by having participants create a food web surrounding a rattlesnake.

Graphic 2D – “Keeled, Beaded, or Smooth?” This interactive emphasized the fact that rattlesnakes have keeled scales by having participants touch reptile skins with different textures.

Graphic 2E – “Shedding the Past” This interactive emphasized the fact that rattlesnakes shed their skin in a single piece by having people touch and feel snake sheds.

Graphic 2F – “To Den or Not to Den” This interactive emphasized the fact that rattlesnakes sometimes den in groups using a magnet board where participants guided magnetic beads (rattlesnakes) back to their den.

Graphic 2G – "Have No Fear" This interactive emphasized the fact that rattlesnakes don't often attack people by having participants spin a wheel to reveal statistics for other risks that are more likely to cause a person harm.



Graphic 2H – “Eggs or Babies?” This interactive emphasized the fact that rattlesnakes have live birth instead of laying eggs by asking participants to look into a box and pressing a button to light up a picture of a female rattlesnake with her newborn offspring.

Study Population

Participants in the study were students currently enrolled in introductory biology courses. This decision was made to reduce potential variance in responses as well as being representative of the student population frequently visiting the space. Students were currently enrolled in either the first or second semester of an introductory biology course series offered at the Tempe campus of Arizona State University during the spring 2019 and fall 2019 semesters. Students enrolled in the same courses with the same instructors were used for both semesters. Class lectures were held relatively close to Reptile Row, making it easy for students to visit the displays. Participation by students was voluntary, but, in all but one course during the spring semester, students were offered extra credit by the instructors for their participation. All participants were 18 years or older.

Pre- and Post-Visit Surveys

A series of pre- and post-visitation surveys were developed for both the control and treatment group. This was done to compare the effect that displays alone versus displays that were enhanced with interactive components had on participant's knowledge, attitude, and value score. The pre- and post-visitation surveys contained the same questions; however a few additional questions were included in the post visitation survey regarding the visit experience. The paired surveys were distributed during both the spring and fall semesters of 2019. Students would take the pre-visitation survey, visit Reptile Row, and then take the post-visitation survey. In spring 2019, Reptile Row had the enclosures and the simple signage (control group), while in fall 2019 the interactive components were incorporated into the same displays Reptile Row (treatment group).

Survey Administration

All surveys were created in and managed using Qualtrics software (Qualtrics Software Company, Provo, UT). Halfway through the spring 2019 semester (control group) and fall 2019 semester (treatment group), students enrolled in the targeted courses received an email that introduced them to the study and provided instructions on how to take the post-survey and how to get to the survey site. Students were given two to four weeks to complete the experiment (pre-survey, visit, and post-survey). The two to four week range was a reflection of the fact that instructors circulated the initial survey to students on different days. The pre-survey was provided to them as a link within the original recruitment email, while the post-survey was accessed via a Quick Response (QR) code or a URL address provided on signs posted at Reptile Row. Pre- and post-visit surveys were linked individually by participant ID number. The surveys were open for the remainder of each semester and ended with a two week period so that professors could distribute extra credit with adequate time.

Analysis

The survey questions were developed based off of previous studies that explored topics such as public attitude and perceptions towards animal species (Kellert, 1993; Lindemann, 2006; Kallman, 2016). Each survey contained 13 general questions. Participants were asked their age range, course section, the frequency at which they had visited the study site (if at all) in the past, the frequency with which they have encountered snakes previously, and their self-assessed knowledge about rattlesnakes. Based on previous research, the frequency at which students visited the space and encountered snakes could have impacted the resultant knowledge scores on the surveys (Falk & Storksdieck, 2005). Asking the students about their previous knowledge of rattlesnakes on a 5 point Likert scale ranging from none at all to a significant amount was intended to assess participants baseline knowledge prior to participating in the experiment. The surveys also included the same 11 knowledge questions on rattlesnake physiology and behavior asked as a series of Yes/No questions. These questions looked at evaluating any difference in knowledge gain after visiting the rattlesnake displays. Each of the knowledge questions were based off of content that was in the display signage already in the space, and similarly, each interactive element was based off of each of one of these facts. Eight questions about the participants attitude regarding rattlesnakes, and eight questions regarding how they value rattlesnakes were then asked on a 5-point Likert scale. Attitude questions aimed to ascertain participants immediate feelings towards rattlesnakes, including likeability, fear, species interest, and initial perceptions. Value questions examined broader and deeper ideologies, including their perceived value of rattlesnakes in the environment, their conflict with humans, and what human roles should be in regards to rattlesnakes. In analyzing the results of the surveys, knowledge, attitude, and value were evaluated separately. A knowledge score was calculated based on the number of correct answers while attitude and value questions were scored and evaluated individually based off of negatively worded questions and positively worded questions. In each instance, the results were compared between the pre and post-visit survey for each individual.

Pre- and post-visit survey data were merged using the R statistical environment (R Core Team, 2016), and all other statistical tests were completed using IBMSPSS Statistics for Windows (IBM Corp., Armonk, NY) version 26. An exploratory factor analysis was run on attitude and value questions to test each item, attitude and value, to see how many different dimensions they each measured. This was also done to verify the question construction for evaluation of attitude or value. Individual dimensions were evaluated for reliability using Cronbach's Alpha test. To assess the impact of control and treatment groups on knowledge, the total number of correctly answered knowledge questions was calculated for each individual, resulting in an overall knowledge score. A paired t-test was then used to compare these scores between pre- and post-visit surveys. Paired t- tests were also used to determine the differences in participant's attitudes and values between pre- and post-visit survey results. These tests were used comparing within pre and pos-survey groups and between the control and treatment group. An independent sample t-test was used to analyze the significance of attitude and value differences between the control and treatment participants.

RESULTS

Survey Response

In spring 2019, 1,152 students were solicited to participate in the survey, while 1,896 students were solicited in the fall. The anticipated response rate for both semesters was 30%. Submitted surveys that were incomplete, duplicates, or had unidentifiable student identification numbers were eliminated. Participants who were in targeted courses during both semesters were identified by the university's student identification numbers and their surveys from the fall (treatment group) semester were removed since they were active participants during the spring (control group) semester. This was to remove any potential prior viewing bias. Additionally, all participants that answered no to the consent question were removed from the study. Due to Institutional Review Board restrictions, students under the age of 18 were also removed from the study, but were able to equally receive extra credit.

After filtering out non-qualifying participants, the total number of participants was 323 for the control pre-survey and 243 for the control post-survey. There were 1067 participants for the treatment pre-survey and 698 for the treatment post-survey. After merging pre- and post-survey data and removing surveys with any missing responses, statistical analyses were performed using 210 participants for the spring (control group) semester and 566 participants for the fall (treatment group) semester. Participants were only included if they had complete responses on their pre and post-survey. The reason for the greater response rate in the fall (30%) versus the spring (18%) is unknown. The average time respondents took to complete the surveys were 3.9, 4.7, 3.8, and 5.2 min for the control pre-survey, control post-survey, treatment pre-survey, and treatment post-survey, respectively.

<u>Participant characteristics</u>

Findings regarding participants characteristics, demographics, visitation, knowledge, and experience are shown in Table 1.

Control pre-survey

Two-thirds (67.6%) of the participants were female and the vast majority of the participants were 18-24 years of age (96.4%). When asked how often they visited the building, most participants answered that they visited the building frequently (43.8%), followed by a few times before (26.7%), not at all (15.7%), and once before (13.8%). When asked how much they know about rattlesnakes, a majority of the population responded a little (61.4%) or none at all (12.9%). Participants were then asked how often they encountered snakes, with nearly half reporting never (48.6%) and a third reporting once a year (31.9%).

Treatment pre-survey

The treatment pre-survey demographics were similar to those of the control pre-survey. Two-thirds (67.1%) of the participants in the treatment post-survey were female, with participant age being similarly dominated by the 18-24 age group (97.7%). Most participants had come to the building frequently (37.6%), with fewer having visited a few times before (23.3%), once before (16.8%), and never before (22.3%). When asked how much they knew about rattlesnakes, most people responded a little (61.8%) or none at all (15.5%). Regarding encounters with snakes, most participants reported never encountering a snake (45.7%) or only encountering a snake once per year (38.7%).

<u>Visitation Experience</u>

Results regarding visitation experience in the control and treatment post-surveys are presented in Table 2. This includes whether participants learned, what participants learned, how much time was spent in the space, if the experience was enjoyed, and whether the participant would return to the space.

Control Post-survey

Responses regarding demographics were similar between the pre- and post-survey. However, when asked how frequently the building had been visited before, knowledge of rattlesnakes, and encounter frequency of snakes, there were some differences. There was some confusion on the question regarding how often students frequented the building, because one of the responses “I have never been there before” was ambiguous in the post-survey because students were required to visit the building prior taking the post-survey. Some, but not all, participants considered the study visit to the building as a previous visit at the time of taking the post-survey. Answers were also slightly varied when asked “how often do you encounter snakes?” This could be explained by the participant considering the visit to the display for this study in their response or having realized between the pre- and post-survey that they encounter snakes more often than they originally thought. As our focus was on the participants' experiences prior to starting this study and the uncertainly of the influence of the study-induced visit to the displays on the participants' responses in the post-survey, we only considered the pre-survey responses to these questions.

When asked if participants had learned something, the majority (89.0%) responded yes. Nearly half of the participants spent 5-10 minutes (48.6%) looking at the displays while a smaller number of individuals spent longer than 10 minutes (18.6%). When asked if participants enjoyed

Table 1: Control and Treatment Pre-Survey Participant Traits

		Control Pre (N=210)		Treatment Pre (N=566)	
Question	Answer choices	Freq.	%	Freq.	%
What class are you taking this for?	BIO 181	2	1.0	83	14.7
	BIO 182	158	75.2	164	29.0
	BIO 281	50	23.8	262	46.3
	BIO 282	0	0	57	10.0
What is your sex?	Male	68	32.4	186	32.9
	Female	142	67.6	380	67.1
What is your age range?	18-24	202	96.2	553	97.7
	25-34	4	1.9	12	2.1
	35-44	3	1.4	1	0.2
	45-54	0	0	0	0
	55-64	1	0.5	0	0
How often have you been to the LSA rattlesnake atrium?	I come to this building frequently	92	43.8	213	37.6
	I have visited a few times before	56	26.7	132	23.3
	I have visited once before	29	13.8	95	16.8
	I have never been there before	33	15.7	126	22.3
How much do you know about rattlesnakes?	A great deal	3	1.4	4	0.7
	A lot	5	2.4	11	1.9
	A moderate amount	46	21.9	113	20.1

	A little	129	61.4	350	61.8
	None at all	27	12.9	88	15.5
How often do you encounter snakes?	Daily	9	4.3	13	2.3
	Once a week	19	9.0	28	4.9
	Once a month	13	6.2	47	8.4
	Once a year	67	31.9	219	38.7
	Never	102	48.6	259	45.7

Note: There were no participants that recorded to be over 65.

their visit, most of the participants responded yes (92.4%). Of these, 57.7% indicated that seeing the animals was their reason for enjoying their visit, while learning about the animals was less of a motivator (9.8%). One person enjoyed the location and two people indicated other reasons, one commenting on the nice looking displays and the other specifically commenting on the connection they had after seeing there was a mother and son rattlesnake on display. Of the 7.1% of participants that indicated they did not enjoy the visit, 13 people stated that it was because they did not like snakes and 2 people stated they did not like the snakes being in small cages. When asked if participants would return to LSA the majority responded yes (87.9%). The students who did not enjoy their experience all stated they would not return.

Treatment Post-survey

All of the demographic questions had similar results between the pre- and post- surveys, but the same uncertainty regarding the influence of the pre-survey on the post-survey was seen in the questions on how often the building was frequented, participants prior knowledge of rattlesnakes, and how frequently participants encountered snakes.

When asked if they had learned something after visiting the displays, the bulk of the participants (94.0%) stated yes. Most of the participants answered that they spent 5-10 minutes (45.8%) looking at the displays, while one third of the group responded 1-5 minutes (30.0%). Similar to the responses regarding whether the participants enjoyed their visit, the majority

(93.3%) responded yes. Of those that enjoyed their visit, they most commonly responded that it was because of seeing the animals (41.3%). The second most common response was that there was more than one reason why they enjoyed their visit, while learning about the animals (7.8%), the location (1.0%), and the interactive components (3.1%) were all infrequent selections. Those who selected "other" reasons for enjoying their visit indicated it was the presence of a specific species or loving everything about the experience as the reason why they enjoyed the visit. Of the 38 individuals (7.7%) that responded that they did not enjoy their visit, 36 of them stated it was because they did not like or were afraid of snakes, while 2 participants commented on their unhappiness with the size of the enclosures. When asked if they would return to visit the displays,

Table 2: Control and Treatment Post-Survey Visitation Experience

		Control Post (N=210)		Treatment Post (N=566)	
Question	Answer choices	Freq.	%	Freq.	%
Did you learn something today?	Yes	187	89.0	532	94.0
	No	23	11.0	33	5.8
	No response	0	0	1	0.2
How long did you spend looking at the displays?	Less than a minute	7	3.3	20	3.5
	1-5 minutes	61	29.0	170	30.0
	5-10 minutes	102	48.6	274	48.5
	Longer than 10 minutes	39	18.6	102	18.0
	No response	1	0.5	0	0
Did you enjoy your visit?	Yes	194	92.4	528	93.3
	No	15	7.1	38	6.7
	No response	1	0.5	0	0
What did you enjoy?	I enjoyed seeing the animals	112	57.7	218	41.3
	I enjoyed learning about the animals	19	9.8	41	7.8
	I enjoyed the location	1	0.5	5	1.0
	I enjoyed the interactive components	NA	NA	16	3.1

	Other	2	1.0	2	0.4
	More than one response	56	28.9	231	44.2
	No response	4	2.1	15	2.9
Will you return to visit the snakes in LSA?	Yes	182	87.9	489	86.5
	No	25	12.1	76	13.5
	No response	3		1	
Did you interact with one of the interactive elements by pushing a button, opening a box, or feeling a texture?	Yes	N/A	N/A	365	64.5
	No	N/A	N/A	201	35.5

the majority stated yes (86.5%). In the treatment post-survey, participants were also asked if they interacted with any one of the interactive elements during their visit, and nearly two thirds (64.5%) responded that they did.

Knowledge questions

Information regarding the participants' knowledge questions can be found in Table 3a-c. Survey participants were asked eleven yes or no questions based on the life history, physiology, and behavior of rattlesnakes. Overall, in the control group, participants answered on average 6.4/11 questions correctly in the pre-survey and 7.1/11 questions correctly on the post-survey (Median 6 and 7, respectively). The difference in the means among the pre and post-survey results was significant $p < .0001$. In the treatment group, participants answered on average 6.3/11 questions correctly in the pre survey and 7.4/11 questions correctly on the post survey (Median 6 and 7, respectively). The difference in the mean number of questions answered correctly among the pre and post-survey results was significant $p < .0001$. There was no significant difference between the control and treatment groups in the change of correctly answered questions from the pre- to post-survey $p > .05$.

Control

In the control group, there was an increase in correct answers from the pre- to post-survey in 9 out of the 11 questions. In 7 out of the 11 questions this change was significant $p < .05$. The majority of participants had correct pre-survey knowledge by answering the statements "rattlesnakes are venomous," (94.3%) "rattlesnakes do not attack people," (81.4%) "rattlesnakes shed their skin," (99.0%) and that "rattlesnakes have keeled scales" (78.5%) correctly. Participants did not have a significant change in answers to these questions over the pre and post-surveys because the majority of participants answered correctly both times.

Treatment

Of the knowledge questions, control and treatment groups had similar baseline knowledge of rattlesnakes in their pre-surveys. In the treatment group, there was an increase in 10 out of the 11 questions, in 8 out of the 11 questions this change was significant $p < .0001$. Like the control group, the majority of participants started out their pre-survey knowing that rattlesnakes are venomous (90.8%) and that rattlesnakes shed their skin (97.7%). Participants did not have a significant change in answers to these questions over the pre and post-surveys because the majority of participants answered correctly both times.

Table 3a: Pre/Post knowledge Control

	Control Pre-survey		Control Post-survey			
	μ	SD	μ	SD	T	P
# of correct answers	6.4	1.5	7.1	1.8	-6.01	p<.00001

n=210, there were 11 knowledge questions evaluated. μ= Mean SD= Standard Deviation

Table 3b: Pre/Post knowledge Treatment

	Treatment Pre-survey		Treatment Post-survey			
	μ	SD	μ	SD	T	P
# of correct answers	6.3	1.5	7.4	2.0	13.02	p<.00001

n=566, there were 11 knowledge questions evaluated. μ= Mean SD= Standard Deviation

Table 3c: Control and Treatment Knowledge Reponses

	Control Pre-survey n=210		Control Post-survey n=210				Treatment Pre-survey n=566		Treatment Post-survey n=566			
	C	I	C	I	T	P	C	I	C	I	T	P
Rattlesnakes are venomous (Yes)	94.3	5.7	92.0	8.0	1.39	.083	90.8	9.2	91.9	8.1	-.802	.211
Rattlesnakes are poisonous (No)	56.2	43.8	62.9	37.1	-2.36	**.009**	53.0	47.0	64.9	35.1	-6.09	**.000**
Rattlesnakes often attack people (No)	81.4	18.6	84.8	15.2	-1.21	.112	82.2	17.8	88.0	12.0	-3.89	**.000**
Rattlesnakes lay eggs (No)	12.4	87.6	24.8	75.2	-4.27	**.000**	9.0	91.0	31.4	68.6	-11.2	**.000**
Rattlesnakes periodically shed their skin (Yes)	99.0	1.0	97.1	2.9	1.41	.079	97.7	2.3	97.3	2.7	.784	.217
Rattlesnakes have keeled scales (Yes)	78.5	21.5	82.4	17.6	-1.41	.080	73.9	26.1	85.5	14.5	-5.81	**.000**
Rattlesnakes rely heavily on hearing compared to other senses (No)	45.2	54.8	51.7	48.3	-1.73	**.042**	46.2	53.8	46.8	53.2	-.247	.402
Rattlesnakes have numerous natural predators (Yes)	62.7	37.3	73.8	26.2	-3.48	**.000**	63.8	36.2	74.4	25.6	-5.30	**.000**
Rattlesnakes den together (Yes)	38.5	61.5	58.9	41.1	-5.35	**.000**	37.3	62.7	61.1	38.9	-9.85	**.000**
Rattlesnakes can be aged by counting the segments of their rattle (No)	19.0	81.0	26.7	73.3	-2.32	**.011**	21.2	78.8	34.3	65.7	-5.87	**.000**
Rattlesnakes have eyelids (No)	51.4	47.6	60.1	39.9	-2.31	**.011**	52.8	47.2	63.9	36.1	-5.17	**.000**

C= Correct number of responses in percent ; I= Incorrect number of responses in percent.

Attitudes towards rattlesnakes

Survey participants were asked a series of questions about their attitudes regarding rattlesnakes; these were asked using a Likert scale with one being “strongly disagree” and five being “strongly agree.” Results related to participant attitudes can be found in table 4a for control group and 4b for treatment group

Control

Paired t-tests were performed on individuals’ pre- and post-survey responses to each attitude question. Across all questions relating to attitude, there was a significant difference between pre- to post-survey average responses ($p < .05$ for all tests). For positively worded questions, control group response averages that were negative in the pre survey moved toward neutral in the post survey. For questions that were negatively worded, the average responses trended more negatively, indicating a more positive attitude towards rattlesnakes.

Treatment

Paired t-tests were performed on individuals’ pre- and post-survey responses to each attitude question. In all except one case, there was a significant difference between answers ($p < .05$ for all tests). Similar to the control group, each question showed a more positive trend in the post survey, and, in the case of the negatively worded questions, the average score shifted lower, showing an improved attitude towards rattlesnakes. The one exception was the statement, “It is impossible for people to love rattlesnakes,” where there was no change in responses.

Table 4a: Frequency Distribution (in Percent) of Attitudes Towards Rattlesnakes in the Control Group

	Pre-survey							Post-survey							T-stat and P-Value	
	1	2	3	4	5	μ	SD	1	2	3	4	5	μ	SD	T	P
It is impossible for people to love rattlesnakes	32.4	42.9	11.4	6.2	7.1	2.13	1.15	41.9	36.7	14.3	3.3	3.8	1.91	1.01	2.74	**.003**
I like rattlesnakes	20.9	17.6	31.9	24.8	4.8	2.75	1.18	11.4	18.6	34.3	27.6	8.1	3.02	1.12	-4.51	**.000**
The best rattlesnake is a dead rattlesnake	30.5	38.6	18.1	5.7	7.1	2.21	1.15	45.7	30.9	15.7	4.8	2.9	1.88	1.03	5.08	**.000**
I would be excited to see a rattlesnake in the wild	22.9	28.1	18.6	23.3	7.1	2.64	1.26	16.7	23.8	28.1	24.3	7.1	2.81	1.19	-2.47	**.007**
I do not like rattlesnakes because they are mean	21.5	39.5	27.1	8.1	3.8	2.33	1.02	25.2	40.5	24.3	6.7	3.3	2.22	1.01	-2.48	**.007**
I do not like rattlesnakes because they could seriously hurt me	8.6	18.1	27.6	34.8	10.9	3.21	1.13	13.3	25.2	24.8	29.5	7.2	2.92	1.17	5.02	**.000**
I have no interest in rattlesnakes	8.2	31.4	29.5	17.6	13.3	2.97	1.16	9.5	35.2	28.6	19.5	7.2	2.79	1.09	2.88	**.002**
I dislike rattlesnakes because I am afraid of them	11.9	23.8	21.9	26.2	16.2	3.11	1.27	16.7	28.6	21.9	24.3	8.5	2.80	1.23	5.15	**.000**

Overall mean for attitudes = 3.18 Pre-Survey 3.41 Post-Survey ; Cronbach's alpha = .941 Bolded items represent significance $p < .05$. Note: Items distributed on a 5-point Likert scale: Strongly Disagree (1), Disagree (2), Neither agree nor disagree (3), Agree (4), Strongly Agree (5).

Table 4b: Frequency Distribution (in Percent) of Attitudes Towards Rattlesnakes in the Treatment Group

	Pre-survey							Post-survey							T-stat and P-value	
	1	2	3	4	5	μ	SD	1	2	3	4	5	μ	SD	T	P
It is impossible for people to love rattlesnakes	41.8	33.9	16.4	4.4	3.5	1.94	1.04	42.4	36.0	11.8	5.8	4.0	1.93	1.06	.273	.392
I like rattlesnakes	18.0	19.4	34.5	23.0	5.1	2.78	1.14	9.0	17.5	36.5	29.0	8.0	3.09	1.07	-9.02	**.000**
The best rattlesnake is a dead rattlesnake	31.1	32.2	23.3	9.0	4.4	2.23	1.12	40.8	34.5	18.7	3.7	2.3	1.92	.97	8.23	**.000**
I would be excited to see a rattlesnake in the wild	24.7	22.1	19.3	26.1	7.8	2.70	1.30	16.1	23.5	24.7	28.1	7.6	2.88	1.20	-4.54	**.000**
I do not like rattlesnakes because they are mean	22.4	36.9	28.3	9.2	3.2	2.34	1.02	24.0	39.4	26.5	8.0	2.1	2.25	.98	2.35	**.009**
I do not like rattlesnakes because they could seriously hurt me	8.5	17.7	22.9	38.5	12.4	3.29	1.15	12.5	26.0	25.1	29.7	6.7	2.92	1.15	8.62	**.000**
I have no interest in rattlesnakes	8.7	33.0	25.4	22.6	10.3	2.93	1.14	10.4	33.7	29.5	19.3	7.1	2.79	1.09	3.56	**.000**
I dislike rattlesnakes because I am afraid of them	13.4	26.2	16.6	31.8	12.0	3.03	1.26	16.4	29.0	21.7	24.4	8.5	2.80	1.22	5.70	**.000**

Overall mean for attitudes = 3.21 Pre-Survey 3.42 Post-Survey ; Cronbach's alpha = .924 Bolded items represent significance $p < .05$. Note: Items distributed on a 5-point Likert scale: Strongly Disagree (1), Disagree (2), Neither agree nor disagree (3), Agree (4), Strongly Agree (5).

Value of rattlesnakes

Survey participants were asked a series of questions about their values regarding rattlesnakes; these were asked using a Likert scale with one being “strongly disagree” and five being “strongly agree.” Results related to participant attitudes can be found in table 5a for control group and 5b for treatment group.

Control

Paired t-tests were performed on individuals’ pre- and post-survey responses to each value question. For all but three questions, there was a significant difference ($p < .05$) between participants’ pre- and post-survey responses. The statements “rattlesnakes should be removed from the wild because they pose a threat to humans,” “I would be glad if rattlesnakes became extinct,” and “rattlesnakes have a right to live” did not change from pre to post survey for the control group. Participants strongly disagreed with the statements “Rattlesnakes should be removed from the wild because they pose a threat to humans” and “I would be glad if rattlesnakes became extinct,” indicating that even initially participants saw ecological value in rattlesnakes and did not feel rattlesnakes were a threat to humans.

Treatment

Paired t-tests were performed on individuals’ pre- and post-survey responses, and, as was the case for the control group, there was a significant difference, $p < .05$, among answers from participants from their pre- to the post-survey responses for all but three questions. The questions that had no significant difference, $p > .05$, were the same three questions with no significant different in the control group - “rattlesnakes should be removed from the wild because they pose a threat to humans,” “I would be glad if rattlesnakes became extinct, and “rattlesnakes have a right to live.”

Table 5a: Frequency Distribution (in Percent) of Values Towards Rattlesnakes in the Control Group

	Pre-survey							Post-survey							T-stat and P-value	
	1	2	3	4	5	μ	SD	1	2	3	4	5	μ	SD	T	P
Rattlesnakes help make the world a better place	4.3	10.0	45.2	32.4	8.1	3.3	.91	1.0	3.3	37.1	38.6	20.0	3.73	.85	-7.97	**.000**
Rattlesnakes should be protected because of their ecological importance.	1.9	1.0	12.4	55.2	29.5	4.09	.79	0	1.0	11.0	49.0	39.0	4.26	.69	-3.57	**.000**
Rattlesnakes should be removed from the wild because they pose a threat to humans	48.1	41.9	7.1	1.9	1.0	1.66	.77	50.4	36.7	9.0	2.9	1.0	1.67	.83	-.284	.388
I would be glad if rattlesnakes became extinct	57.6	27.1	11.9	2.4	1.0	1.62	.86	55.7	28.5	12.9	2.4	0.5	1.63	.83	-.303	.381
We have a responsibility to protect all species including rattlesnakes	0.9	1.4	14.3	31.0	52.4	4.32	.84	1.0	3.3	11.9	39.0	44.8	4.23	.86	1.71	**.045**
Rattlesnakes have a right to live	0.5	1.4	6.2	38.1	53.8	4.43	.72	0	1.0	6.6	38.1	54.3	4.45	.66	-.569	.285
I have a role in protecting rattlesnakes	9.5	11.4	41.4	24.4	13.3	3.20	1.11	3.3	7.6	36.2	33.3	19.6	3.58	.99	-6.16	**.000**
Rattlesnakes are valuable to the ecosystem	0	1.0	15.7	44.3	39.0	4.21	.74	0	0.5	11.9	41.9	45.7	4.32	.70	-2.88	**.002**

Overall mean for attitudes = 4.04 Pre-Survey 4.16 Post-Survey ; Cronbach's alpha = .934 Bolded items represent significance p< 05. Note: Items distributed on a 5-point Likert scale: Strongly Disagree (1), Disagree (2), Neither agree nor disagree (3), Agree (4), Strongly Agree (5).

Table 5b: Frequency Distribution (in Percent) of Values Towards Rattlesnakes in the Treatment Group

	Pre-survey							Post-survey							T-stat and P-value	
	1	2	3	4	5	μ	SD	1	2	3	4	5	μ	SD	T	P
Rattlesnakes help make the world a better place	2.8	8.8	48.6	33.9	5.8	3.31	.82	1.9	4.6	29.9	45.9	17.7	3.73	.87	-13.4	**.000**
Rattlesnakes should be protected because of their ecological importance.	1.1	2.1	17.0	55.8	24.0	4.00	.77	1.1	1.9	9.0	49.8	38.2	4.22	.77	-7.22	**.000**
Rattlesnakes should be removed from the wild because they pose a threat to humans	47.5	37.6	12.4	2.1	0.4	1.70	.79	48.2	37.3	11.1	2.8	0.6	1.70	.82	0	.500
I would be glad if rattlesnakes became extinct	53.5	29.2	13.4	2.5	1.4	1.69	.90	56.4	27.9	11.5	3.9	0.3	1.64	.86	1.45	.074
We have a responsibility to protect all species including rattlesnakes	1.4	2.5	10.8	37.1	48.2	4.28	.86	1.4	2.5	12.5	40.8	42.8	4.21	.86	2.01	**.022**
Rattlesnakes have a right to live	1.3	0.7	7.6	38.5	51.9	4.39	.76	1.4	1.2	8.3	38.9	50.2	4.35	.80	1.26	.102
I have a role in protecting rattlesnakes	5.6	16.1	42.8	26.7	8.8	3.17	.99	3.0	9.9	37.3	33.9	15.9	3.50	.97	-8.67	**.000**
Rattlesnakes are valuable to the ecosystem	0.5	1.7	13.4	49.6	34.8	4.17	.75	1.2	1.4	8.7	47.3	41.4	4.26	.77	-2.97	**.001**

Overall mean for attitudes = 3.99 Pre-Survey 4.12 Post-Survey ; Cronbach's alpha = .922 *Bolded items represent significance p< .05. Note: Items distributed on a 5-point Likert scale: Strongly Disagree (1), Disagree (2), Neither agree nor disagree (3), Agree (4), Strongly Agree (5(.

Attitude Analysis

The factor analysis for attitude of both the control and treatment groups revealed two dimensions (Table 6a-b), however, the second factor only pulled out one item which is not enough to measure a dimension and was thus eliminated. The identified dimension measured attitudes towards rattlesnakes. The attitudes towards rattlesnakes in the control group (questions 2a-8a and 2b-8b) had a Cronbach's alpha score of 0.941 (0.940 with item 1a and 1b). The attitudes towards rattlesnakes in the treatment group (questions 2a-8a and 2b-8b) had a Cronbach's alpha score of 0.933 (0.924 with item 1a and 1b).

Table 6a: Factor analysis of control attitude questions with varimax rotation

	Component	Factor 1
Pre-Survey	1a. It is impossible for people to love rattlesnakes	.454
	2a. I like rattlesnakes	**.826**
	3a. The best rattlesnake is a dead rattlesnake	**.741**
	4a. I would be excited to see a rattlesnake in the wild	**.669**
	5a. I do not like rattlesnakes because they are mean	**.674**
	6a. I do not like rattlesnakes because they could seriously hurt me	**.768**
	7a. I Have no interest in rattlesnakes	**.803**
	8a. I dislike rattlesnakes because I am afraid of them	**.817**
Post-survey	1b. It is impossible for people to love rattlesnakes	.407
	2b. I like rattlesnakes	**.766**
	3b. The best rattlesnake is a dead rattlesnake	**.620**
	4b. I would be excited to see a rattlesnake in the wild	**.695**
	5b. I do not like rattlesnakes because they are mean	**.724**
	6b. I do not like rattlesnakes because they could seriously hurt me	**.764**
	7b. I have no interest in rattlesnakes	**.787**
	8b. I dislike rattlesnakes because I am afraid of them	**.849**

Eigenvalue= 8.310 ; Percentage of variance explained= 51.937%

Table 6b: Factor analysis of treatment attitude questions with varimax rotation

	Component	Factor 1
Pre-Survey	1a. It is impossible for people to love rattlesnakes	.316
	2a. I like rattlesnakes	**.804**
	3a. The best rattlesnake is a dead rattlesnake	**.700**
	4a. I would be excited to see a rattlesnake in the wild	**.664**
	5a. I do not like rattlesnakes because they are mean	**.728**
	6a. I do not like rattlesnakes because they could seriously hurt me	**.712**
	7a. I have no interest in rattlesnakes	**.733**
	8a. I dislike rattlesnakes because I am afraid of them	**.797**
Post-survey	1b. It is impossible for people to love rattlesnakes	.354
	2b. I like rattlesnakes	**.794**
	3b. The best rattlesnake is a dead rattlesnake	**.681**
	4b. I would be excited to see a rattlesnake in the wild	**.677**
	5b. I do not like rattlesnakes because they are mean	**.715**
	6b. I do not like rattlesnakes because they could seriously hurt me	**.721**
	7b. I have no interest in rattlesnakes	**.713**
	8b. I dislike rattlesnakes because I am afraid of them	**.896**

Eigenvalue= 7.741 ; Percentage of variance explained= 48.380%

Value Analysis

A similar factor analysis was run for the value questions. The control group resulted in a two-dimension result (Table 7a), however, the first component cross loaded and was the only item that loaded onto the second dimension and was thus eliminated. The identified dimension represented general values towards rattlesnakes and included all items except 1a. The Cronbach's alpha score for value of rattlesnakes (questions 2a-8a and 1b-8b) in the control group was 0.934. The treatment group resulted in a three-dimension result (Table 7b), however, only item 7a and 7b cross loaded onto a second and third dimension and were thus eliminated. The identified dimension was referred to as general values towards rattlesnakes and included all questions except 7a and 7b. The Cronbach's alpha score for value of rattlesnakes (without item 7a or 7b) in the treatment group was 0.922.

7a: Factor analysis of control value questions with varimax rotation

	Component	Factor 1
Pre- Survey	2a. Rattlesnakes should be protected because of their ecological importance.	**.723**
	3a. Rattlesnakes should be removed from the wild because they pose a threat to humans	**.768**
	4a. I would be glad if rattlesnakes became extinct	**.750**
	5a. We have a responsibility to protect all species including rattlesnakes	**.716**
	6a. Rattlesnakes have a right to live	**.731**
	7a. I have a role in protecting rattlesnakes	**.623**
	8a. Rattlesnakes are valuable to the ecosystem	**.811**
Post-survey	1b. Rattlesnakes help make the world a better place	**.697**
	2b. Rattlesnakes should be protected because of their ecological importance.	**.817**
	3b. Rattlesnakes should be removed from the wild because they pose a threat to humans	**.723**
	4b. I would be glad if rattlesnakes became extinct	**.689**
	5b. We have a responsibility to protect all species including rattlesnakes	**.738**
	6b. Rattlesnakes have a right to live	**.770**
	7b. I have a role in protecting rattlesnakes	**.646**
	8b. Rattlesnakes are valuable to the ecosystem	**.803**

Eigenvalue= 8.422 ; Percentage of variance explained= 52.635%
Note: Item 1a cross loaded onto a second factor and was removed from further analysis.

Table 7b: Factor analysis of treatment value questions with varimax rotation

	Component	Factor 1
Pre-survey	1a. Rattlesnakes help make the world a better place	**.645**
	2a. Rattlesnakes should be protected because of their ecological importance.	**.730**
	3a. Rattlesnakes should be removed from the wild because they pose a threat to humans	**.710**
	4a. I would be glad if rattlesnakes became extinct	**.705**
	5a. We have a responsibility to protect all species including rattlesnakes	**.614**
	6a. Rattlesnakes have a right to live	**.676**
	8a. Rattlesnakes are valuable to the ecosystem	**.739**
Post-survey	1b. Rattlesnakes help make the world a better place	**.685**
	2b. Rattlesnakes should be protected because of their ecological importance.	**.760**
	3b. Rattlesnakes should be removed from the wild because they pose a threat to humans	**.670**
	4b. I would be glad if rattlesnakes became extinct	**.683**
	5b. We have a responsibility to protect all species including rattlesnakes	**.745**
	6b. Rattlesnakes have a right to live	**.726**
	8b. Rattlesnakes are valuable to the ecosystem	**.773**

Eigenvalue= 7.754 ; Percentage of variance explained= 47.337%
Note: Item 7a and 7b, “I have a role in protecting rattlesnakes,” cross loaded onto a second and third factor and were removed from further analysis.

DISCUSSION

Overall, visiting the self-guided rattlesnake displays increased visitor's knowledge, attitude, and values. However, adding interactive elements did not enhance the effects of visiting displays and consequently the second hypothesis, "adding interactive elements to displays further enhances effect on visitor knowledge, attitude, and value than displays without elements" is not supported. The impact of visiting the animal display regardless of whether interactive elements were present or not, was significant for both groups and is reflected in the change in knowledge, attitude, and values. Consequently, these findings support the first hypothesis. "controlled viewing of animals that are often looked at in a negative manner will induce positive learning, attitude, and value outcomes regarding those animals." The third hypothesis "adding interactive elements to displays will increase a visitors time spent at the exhibit, increase interest in repeated visitation, and increase positive visit enjoyment," was also rejected because the addition of the interactive elements did not impact any of these, instead the visit to the display showed high reported enjoyment, dwell time, and interest in visiting again.

Knowledge

Across both the control and treatment groups, there was a significant difference in performance between pre and post-survey knowledge questions, supporting the conclusion that visiting the exhibits improved visitor's knowledge. Pre-survey results of the control and treatment groups showed a similar number of correctly answered questions, while the post surveys of both the control and treatment groups resulted in a higher number of correctly answered questions. The same statements in both the control and treatment, "Rattlesnakes lay eggs", "Rattlesnakes can be aged by counting the segments on their rattle" and "Rattlesnakes rely heavily on hearing compared to other senses" had more than 50% of participants respond incorrectly in both the pre and post-surveys. This was unexpected, but "Rattlesnakes can be aged by counting the segments on their rattle" and "Rattlesnakes rely heavily on hearing compared to other senses" were anticipated originally to not have significance in the post survey as they did not have an interactive element associated with them that addressed these topics. Rattlesnakes being aged by the segments in their rattle is a common myth; students may have made the assumption they knew the answer. However, alternative learning methods or varied examples easily remedies misconceptions and can aide in the re-learning process (Mazano, 2010).

While the answers to each of the questions were presented at the displays for both the control and treatment groups, it was important to broadly evaluate how effective the displays were at getting these points across because some question were more successfully answered than others. Any new learning is ultimately constructed from prior knowledge and appropriate motivation, so understanding what people already knew, what they were learning in the space, and what was lacking are all essential in evaluating the visitor experience (Falk & Dierking, 2000). For some of the questions, each had a high number of incorrect answers, regardless of the visit. Participants may have been assuming they knew the correct response and were not seeking an answer while visiting. Since there is a limited human-animal relationship regarding snakes, presence of some wrong ideas as a result of folklore, for example, can influence knowledge and conservation-minded behaviors towards snakes (Ohman, 2003). These misconceptions can lead to wrong ideas that could influence attitudes, especially towards species like snakes, which are so prevalent in folklore. Knowledge and a positive attitude are important for promoting learning, eventually leading visitors to conservation-minded behavioral decisions (Pooley et al., 2000). By looking at “facts” that could have been previously learned incorrectly due to social or cultural influences, we can better understand how to modify existing signs or interpretive tools to better educate audiences and promote more accurate understandings of animals that can assist in conservation support of them.

Visitors have been shown to possess a broad range of prior knowledge and this is impactful because this influences what the individual will learn from the visit and how they will apply new knowledge to their existing knowledge base (Falk et al., 2003). The visitors’ prior knowledge is a primary domain impacting how the visitor will respond to the environment

(Ausubel, 1968; Iozzi, 1989). Prior knowledge and its impacts on the visitor experience has been widely examined; however, the pre-existing interest has been shown to be just as impactful (Falk & Storksdieck, 2005). Visitor interest was not evaluated for the participants in this study nor was it a focus, but given how related it is to prior knowledge there is much that could have influenced participant responses to knowledge questions if the participant was significantly more interested or overall uninterested in the subject of rattlesnakes. There is still a gap in understanding how previous experiences impact the learning outcomes of visitors (Falk & Storksdieck, 2005).

Attitude

In the control group, there was a significant difference in the mean score for all eight attitude questions between pre and post-survey responses. For positively worded questions, response averages that were negative in the pre-survey moved toward neutral in the post-survey. For questions that were negatively worded, the average responses became more negatively, indicating a more positive attitude towards rattlesnakes. Overall, in both control and treatment groups, students showed significantly more positive attitudes in terms of rattlesnake likability, interest, and favor after visiting the rattlesnake displays.

This change is attitude is relevant because by having visitors engage with animals from across the globe in a meaningful and personal way, regardless of interactive features, there is an opportunity for connection that helps to promote visitor interest in species conservation (Swanagan, 2000; Fernandez, 2009). For species that are traditionally viewed negatively, promoting positive attitude change helps increase species awareness and decreases human-wildlife conflict (Carr, 2006; Bruskotter, 2007; Pinheiro, 2016). A positive change in attitude can also help restructure a learner's previously held misconceptions through focused instruction and further experiences (Strike et al., 1992; Falk et al., 2003). Thus, when constructing displays, attitudes should be considered, especially if the goal of a display is to eliminate misconceptions. Those attitudes that have been influenced by socio-cultural heritage or religion, specifically towards snakes, should not be disregarded and in terms of promoting positive attitudes towards these species, this must be considered (Ceriaco, 2012; Ohman, 2003). Interpretive elements that clarify wrong perceptions about dangers of an animal and elaborates on the usefulness of species in the ecosystem can provide a more accurate representation of a species' characteristics, promoting positive attitudes instead of fear (Ceriaco, 2012). Positive attitudes towards reptiles, including snakes, is essential for supporting conservation of these species as people are more likely to donate and promote species that they like over those that they dislike (Pinheiro, 2016).

Value

In the control group, there was a difference in the average response in five of the eight value statements between pre and post-survey responses. Overall, participants had a positive value towards rattlesnakes in the pre-survey and the positive responses were even stronger after visiting the displays. The treatment group showed similar results, with statistically different scores for five of the eight value statements. For both the control and treatment groups, the same three statements had strong pre-survey responses that precluded a statistically significant increase from the pre to the post-surveys.

Increased value as a result of visiting the display relevant because promoting deeper conservation minded values has shown to lead visitors to engage in conservation-based behavior up to six months after an experience (;Orams, 1997; Howard, 1999; Ballantye et al., 2005). This helps reduce potential human-wildlife conflict with rattlesnakes by creating a value that may have previously been absent, thus increasing conservation mindedness (Pinheiro, 2016). Animal displays where visitors are able to have an up-close experience or even and eye-to-eye contact with an animal has shown to improve the value visitors have towards that animal (Powell, 2014). The eye-to-eye experience that this display's visitors were able to have may have been why there was no further benefit to visitor value as a result of adding the interactive elements, suggesting value was created from this up close experience alone. Institutions play a significant role in reinforcing prior knowledge, attitudes, and values and ultimately help to consolidate mindsets that influence a visitor's perceived value towards an object or topic (Falk, 2004; 2005). In zoological settings, it has been shown that visiting animals helps reinforce attitudes and values towards conservation (Falk et al., 2007). Conservation organizations, specifically, must continue focusing on providing unique experiences that help make connections and encourage further conservation-based learning once visitors go home (Falk et al., 2007; Van Winkle, 2014). By utilizing rattlesnakes, a predominant group species native to the area where this study was conducted, participants may have been able to connect more because of the local relevance. Some tools that can help facilitate connections are post-visit action resources, such as a website with information on how to make informed decisions or suggestions on how visitors can learn more at home. Post-visit action resources help visitors engage and put what they learned into real world scenarios; this has implications that positively affected the visitors next free-choice learning experience (Bueddefeld and Van Winkle, 2018).

Dwell time

The enhanced display did not lead to an increased dwell time, as self-reported time spent at the displays was similar for the control and treatment groups' post surveys. Roughly 30% of both groups spent 1-5 minutes looking at the displays and 48.6% (control) and 48.5% (treatment) spent 5-10 minutes looking at the displays. Additionally, 18% of participants indicated they spent longer than 10 minutes at the displays and only 3% in both control and treatment groups reported spending less than a minute at the displays. Attraction is defined as the ability of a display to hold a visitor's attention for more than 5 seconds (Boisvert and Slez, 1994). Attraction and holding time both heavily influence the success of a visitor's learning experience and further engagement within the museum (Koran and Koran, 1983; Screven, 1986). Further engagement with an exhibit includes spending more time reading, interacting with, talking about, or manipulating an exhibit (Boisvert and Slez, 1994). Average holding time spent at a science and technology based exhibit has been recorded to be less than a minute with the next highest percentages being between 1 and 5 minutes (Sandifer, 2003). In this study, the rattlesnake displays held the attention of more than two-thirds of participants for more than 5 minutes. This is significant as increased dwell time has been shown to further visitor learning and engagement (Falk, 1983; Boisvert and Slez, 1994). This may explain why participants showed gains in knowledge, values, and attitudes across control and treatment groups.

The fact that we observed high dwell time at our displays is even more intriguing given that rattlesnakes are non-charismatic animals that typically have negative connotations associated with them and are inactive most of the time. These factors have been previously shown to decrease dwell time and have been stated as reasons for low visitor interest in displays (Hein, 1998; Fernandez, 2009). Previous research has also shown that the exhibits with the greatest attraction and holding capabilities are generally supported by an in-person interpreter (Boisvert and Slez, 1994). Having an increased dwell time for visitors in a free-choice learning environment with an inactive non-charismatic animal exhibit contradicts these previous findings by suggesting that there is a value in viewing animals up close regardless of the presence of interactive elements. This increase in dwell time may be a result of being able to view the rattlesnakes safely from such a close proximity and could have also benefitted from the exhibit anatomy and spacing (Bitgood, 1992). Zoological facilities can benefit by having exhibit areas spaced in a way that allows for easy maneuverability by the visitor and by having individual displays constructed in a way that is attractive and enticing (Bitgood, 1992; 2016). This can be enhanced further by promoting more up-close viewing opportunities especially with non-charismatic animals in order to increase knowledge and promote conservation-minded behavior, as has been previously documented for up-close animal viewing exhibits (Kisiel et al., 2012).

Interactive Element Utilization

Only two-thirds of the participants reported to have interacted with the display enhancements. The interactive elements were not as impactful on visitor knowledge, attitude, or value as originally predicted; thus, the second hypothesis was rejected. The interactives were also not significantly impactful on an increase in dwell time, increase repeated visitation or visitor reported enjoyment. Instead, the displays themselves seemed to impact these regardless of the presence of the interactive elements; thus, the third hypothesis was also rejected. The interactive elements failure to have a significant impact may have been because they were not made specifically to hold attention but, instead, to attract attention and be accessible. However, attention holding capacities can enhance the impact of the display by creating a memorable experience or positively impacting the displays learning capabilities (Bitgood, 1992; Boivert and Slez, 1995; Falk, 2004; Bitgood, 2016). It has been shown that paired interactive exhibits might induce greater visitor learning ,such as having one exhibit attracting via a large visual and another exhibit holding a visitor's attention with a game or activity (Boisvert and Slez, 1995). While the specific interactive elements for the study may not have made a significant impact, that does not eliminate the possibility that different interactive elements or varied placement would have an impact. However, our results do demonstrate that the display in itself can induce a significant impact on visitors.

This study was unique in that this was a self-guided experience involving non-charismatic animal displays. A major limitation of self-guided experiences is that visitors will only take away what they are motivated to interact with (Falk, 2010). Previous studies have also explained the challenges of engaging and teaching the public with a negatively perceived non-charismatic animal, specifically snakes (Kellert, 1980; Kellert, 1993; Knight, 2008; Powell, 2014). However, in both the control and treatment groups, 89% and 94% of the participants, respectively, said that they learned something. When asked about what specifically they learned, the answers were diverse. While this was self-reported, it was validated by having an increase in the number of correctly answered knowledge questions. Over 90% in both control and treatment groups also reported to have enjoyed their visit, and the majority of the participants reported their reason to be they enjoyed seeing and learning about the rattlesnakes. A majority of participants in both groups also reported "yes" to their willingness to return to the displays again (87.9% and 86.5% for the control and treatment groups, respectively). These findings demonstrate that the free-choice space was highly successful in providing a memorable and enjoyable experience. This is significant because, by having visitors engage with animals in a meaningful and personal way, regardless of interactive features, there is an opportunity for connection that helps to promote visitor interest in species conservation (Swanagan, 2000; Fernandez, 2009).

Our findings have important conservation implications, especially for non-charismatic species such as rattlesnakes, because they show that self-guided displays can promote learning and an improvement in attitudes and values. Learning from a museum or zoological setting cannot be easily defined, and there must be broader accommodations for visitors and more holistic research in order to fully understand how the visitor engages with an exhibit (Falk and Dierking, 2000; Falk, 2004; 2010). Every free-choice learning experience is unique, so by providing more varied interpretive techniques and engagement opportunities, the various learning preferences among visitors are more likely to be provided. But for the scope of this study, the interest in these animals was clear, and, even in a free-choice environment focusing on non-charismatic species, the displays positively influenced visitor knowledge, attitude, and values.

Limitations

While the results of this study demonstrate an impact on knowledge, attitude, and value from visiting the live animal display, there were several limitations to the study. The first limitation was that the population of the participating group was quite homogenous. The study population consisted of only biology students of similar age and education. While there was no effect of the presence of interactive elements for this population, our findings could have been different if our participants were family groups, younger school groups, or older demographics (Hein, 1998; Jeffery, 1996; Rennie, 2006; Fernandez, 2009; Kisiel, 2012). Secondly, the motivation for viewing the displays in our study was likely different than the motivation visitors have when attending a museum exhibit. In a museum or zoo setting, a visitor is motivated enough that they are willing to pay an entrance fee to view exhibits. However, participants in our study may not have shared the same level of motivation, as the displays were free to the public and students were provided compensation in the form of extra credit for viewing the displays. Consequently, the desire for learning and overall engagement may have been different between our study population and visitor populations more broadly.

There was also a limitation on the kinds of interactives that were used. Funding was limited and so were materials; thus, complex technological interactives were not feasible for this study. Even the size of the interactive elements was limited because of the space available in a thoroughfare corridor with numerous classroom and office doors. The last limitation was that there was no true control for the control group. The study could have been modified to have a group of students take both surveys without having visited the display to see whether there was any difference in answer response just from taking the survey twice.

Further Research

There are many studies that could build off of the results of this study, and, together, they could provide great insight into how museums and zoological facilities can enhance their learning environments and highlight the importance of self-engagement in their audiences. While this study focused on effects of the presence of interactive elements in general, future studies could evaluate traits of interactive elements that make them more or less engaging. The Philadelphia-Camden Informal Science Education Collaborative defined seven exhibit characteristics that were necessary for successful interaction by visitor groups and, while these were considered in developing this study's interactive elements, there are numerous other classifications for exhibit design and what is found to be effective (Bitgood, 1992; Boivert and Slez, 1995; Sandifer, 2003 Bitgood, 2016). This study's specific characteristics did not analyze attracting power, holding power, or even holding time on each specific interactive. There is a challenge to measuring specific characteristics like these directly without interrupting the flow of the learning experience; thus, future research should consider more discreet ways to directly observe and measure attracting power, holding power, or holding time of an exhibit (Falk, 1983; Boisvert and Slez,1994). Consequently, instead of looking at exhibition spaces as a whole as was done in this study, a complimentary study looking at individual exhibits and their interactives could be informative. Exhibit characteristics that contributed to exhibit effectiveness and attention holding can be defined by four categories: technological novelty, open-endedness, user-centered-ness, and sensory stimulation (Sandifer, 2003). The specific interactives used during this study were not categorized nor made to fit any specific category, which could have contributed to the lack of significance in effectiveness of the interactives being added.

One implication that this study stressed was the importance of rattlesnake species displays. Experiences with nature has been shown to increase positive attitudes, but only for large charismatic carnivores or other megafauna such as elephants (Swanagan, 2000; Roskaft, 2003). One element that could be added to all displays with inactive animals is an informative graphic explaining animal inactivity to guests and use that behavior itself as a learning opportunity for interpretation. This also has benefits on the visitor's perception of the animal's welfare (Margulis, 2003; Sherwen, 2019). From a conservation standpoint, science centers, museums, and zoological facilities have promoted stewardship among visitors through positive animal encounters, which can help with post visit animal interactions and scientific reasoning (Kisiel, 2012). Although formal education programs are undoubtedly important, they contribute minimally to the public's understanding of environmental issues, creating a need for nature-based institutions (Falk, 2001; Falk and Storksdieck, 2005). There is also a need for free-choice learning environments in an informal education setting as people only learn roughly 3% over their lifetimes in a formal educational setting (Falk and Dierking, 2002). Free-choice learning was successful in this study and has implications for potential impacts in similar settings broadly. One area that can be further explored is looking at long-term effects of visits and experiences on behavior changes post-experience. This would help guide the field into how we can better connect visitors with additional learning materials and options for furthered learning away from the facility (Ballantyne and Packer, 2011). While measurable attitude changes and value changes towards an exhibition have implications for promoting changes in visitor behavior, it is not easily measured and there is little evidence on how effective an exhibition is at actually changing behavior post visit (Powell, 2014). Additionally, there is variation in a visitor's experience, background, and motives; thus, individuality is broad (Rennie, 2006). This variability has historically made measuring outcomes in some free-choice learning environments challenging (Falk et al., 2003). Yet, previous findings suggest that increase in knowledge and learning creates more of an affinity for species and nature, creating more opportunity for impact on a larger scale (Kellert, 1993).

Conservation requires an understanding of both the ecology of the species and the social connection to the species and environment. However, most conservation research focuses on the ecological aspects. This creates a large gap in understanding of how the public views and interacts with nature (Kallman, 2017). By developing exhibits with high emotional impact, we can be more effective at communicating important messages, such as conservation messaging, to visitors (Jeffery et al., 1996). Free-choice learning opportunities among institutions can all work collectively to help visitors make informed decisions for the benefit of the environment and should be encouraged for the visitors (Ballantyne et al., 2003). There is still much to be learned about effectiveness of learning and how different scenarios and settings impact intellectual development. Given the uncertainties, an emphasis should be put on providing a variety of learning opportunities to include interactive and passive, as well as self-guided and staff-assisted, approaches in order to meet the learning preferences that different individual visitors have and thus create the most effective learning environments.

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APPENDIX A

IRB CONFIRMATION DOCUMENTS

EXEMPTION GRANTED

Dale Denardo
OKED: Operations (OPS)
480/965-3325
denardo@asu.edu

Dear Dale Denardo:

On 1/28/2019 the ASU IRB reviewed the following protocol:

Type of Review:	Initial Study
Title:	Educational and Influential Impacts of Adding Interactive Elements to Self-Guided Public Displays
Investigator:	Dale Denardo
IRB ID:	STUDY00009523
Funding:	None
Grant Title:	None
Grant ID:	None
Documents Reviewed:	• Raffle survey- SEPARATE FROM STUDY SURVEY, Category: Other (to reflect anything not captured above); • Student Email, Category: Recruitment materials/advertisements /verbal scripts/phone scripts; • Masters Thesis- Questions DD MB.pdf, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • Danielle Trussell- Recruitment, Category: Recruitment Materials; • Danielle Trussell- Social Behavioral Protocol, Category: IRB Protocol; • Danielle Trussell- Consent, Category: Consent Form;

The IRB determined that the protocol is considered exempt pursuant to Federal Regulations 45CFR46 (2) Tests, surveys, interviews, or observation on 1/28/2019.

In conducting this protocol you are required to follow the requirements listed in the INVESTIGATOR MANUAL (HRP-103).

Sincerely,

IRB Administrator

cc: Danielle Trussell
Dale Denardo
Christian Wright
Megha Budruk