Using place-based art education to engage students in learning about food webs

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ABSTRACT

Integrating art into science as a means of involving students in learning about their environment offers the promise of engaging students both cognitively and emotionally. However, few studies have investigated the use of art as a learning and assessment tool in science. As such, we conducted a research study with 4th and 5th grade students at a rural school district. Our goal was to assess the impact of a place-based art and science activity on student learning about trophic levels (food webs) centered on local snakes. Activities included a lesson on trophic levels, a guided field trip to view live rattlesnakes, a native plant garden, and examples of local wildlife. Students were then instructed to paint a snake in its local environment featuring three trophic levels. Pre- and post-activity artwork and surveys were used to score student knowledge and perceptions about science, art, and local wildlife. Qualitative data was collected from focus group interviews of school administrators, teachers, and parents. We found that the students' understanding of ecosystem components improved, and they were able to transfer their knowledge and use of scientific terminology to other situations. In addition, the activity generated excitement, interest, and curiosity among the students, teachers, and parents. Thus, engaging students in place-based art experiences is useful for enhancing student understanding of trophic-level concepts and can be applied similarly to other science lessons

Keywords: Food webs, Place-based instruction, Art Instruction, Environmental Art

INTRODUCTION

Today's children are in the middle of an odd incongruity. On the one hand, overwhelming percentages of children of all economic levels have access to mobile devices and use them for playing games and accessing the Internet (Kabali et al, 2015, Kumi-Yeboah & Campbell, 2015, Lenhart, 2015). In addition, virtual reality goggles have become a top seller with nearly 200 million units expected to be sold by 2020 (Gaudiosi, 2016). On the other hand, there have been steady declines in attendance at nature-based national parks, and state parks have seen their attendance stagnate (Stevens, Moore, Markowski, 2014, Smith & Leung, 2015). Today, children can quickly access facts about the Amazon rain forest and even visit it through virtual reality. However, few can tell you more than a few basic facts about the wildlife in their local environment (Louv, 2005, Pells, 2015). As Louv (2005) further observes,

> Within the space of a few decades, the way children understand and experience nature has changed radically. The polarity of the relationship has reversed. Today's kids are aware of the global threats to the environment, but their physical contact, their intimacy with nature is fading (p.1).

To foster curiosity and appreciation for wildlife and the environment, techniques beyond standard textbook examples are necessary. Animal adaptations and food webs are core concepts in grade school science standards, but textbooks present these topics in a linear fashion with animals or habitats that may be unfamiliar to some students.

Wildlife science programs have long endeavored to enable their school children to understand and value the contributions of wildlife to ecosystems. Previous studies in wildlife education in school settings have used inventive strategies to foster environmental literacy, social responsibility, and sustainability. Lyamuya et al. (2013), for example, reports on a program provided to 355 elementary students in rural communities in Northern Tanzania on the identification of large carnivores with an emphasis on African wild dogs and their role and purpose within the food web. The four day program consisted of a pretest on day 1, short lectures, films, and food web games on days 2 and 3, and a posttest on day 4. At the end of the program, significantly more school children correctly identified carnivore species than before. Also following the program, significantly more students were able to identify environmental threats to African wild dogs and their importance to the ecosystem.

Using a game-based technology approach, Lu and Liu (2015) investigated an augmented reality game app to teach students about marine wildlife in Taiwan. This four-day program also consisted of pretest and post-test on days 1 and 4 respectively. On Day 2, students were introduced to the app and engaged in interactive storytelling using the app to learn about the water cycle. On Day 3, students participated in augmented reality games where they identified fish characteristics relative to their habitat. This study found that students' knowledge of marine wildlife also was significantly improved from pretest to posttest.

While previous studies illustrate some creative and innovative approaches to wildlife education, engaging students in the arts enables students to use multiple modalities to process and synthesize information leading to deeper and richer meaning. This study examines the juxtaposition of an art integration program grounded in the philosophies of eco-art and place-based science education on student learning about native snakes and their ecosystems.

LITERATURE REVIEW

The major purpose of the present research is to investigate the use of an interdisciplinary approach to instruction which links science and art with a focus on place-based education on students' understanding of trophic levels in the local ecosystem. This review of the literature will examine the strengths of art as an integral means of not only learning but also, demonstrating what has been learned. Then, this review will examine the influence of the environmental art movement as a means of engaging children in meaningful understandings and concern for the environment. Finally, this review will examine the capacity of the place-based education movement to involve children in learning about complex science concepts through local ecosystems.

Arts in the curriculum

Although many consider the arts to be adjunct to the curriculum, increasingly integrating the arts into the curriculum is seen as an essential element of a well-rounded program of study. The Kennedy Center ArtsEdge education network defines arts integration as "an approach to teaching in which students construct and demonstrate understanding through an art form. Students engage in a creative process which connects an art form and another subject area and meets evolving objectives in both " (Silverstein & Layne, n.d., para 1). The goal of arts integration is to create rich learning environments that deepen knowledge within the content field while cultivating an appreciation for various art forms and fostering enthusiasm for learning. The roots of the arts integration movement can be traced to Dewey (1934) who theorized that the creative thinking inherent in the aesthetic experience of art enabled students to negotiate deeper meaning in their learning. Curricular designs that feature arts integration provide a variety of strategies for students to access content and to express understanding. This leads to increased student ownership, and engagement with academic content (Bellisario & Donovan, 2012).

New patterns of thinking become evident when the arts are integrated into the curriculum. Marshall (2016) proposes that arts integration projects "mingle analytical, logical, and linear reasoning with nonlinear and associative thinking (p. 17). This type of thinking, she further maintains, enables integrative thinking where students are using poetic logic or the ability to make connections between seemingly unrelated things. Arts integration projects typically combine the cognitive tools, frameworks, and perspectives of dualistic domains creating a synergy of ideas and insights (Schulz, 2008). Efland (2002) supports this perspective maintaining that an integrated curriculum "is the attempt to enhance and enlarge the learner's power of understanding by enabling him or her to see connections between and among domains of knowledge" (p. 284). Further, integrated curricular designs using the visual arts enable students to engage in representational fluency or the ability to use different symbolic systems to represent meaning (Donovan & Pascale, 2012). As students gain understanding of content, they must draw on critical thinking skills to transform their insights not into the traditional text forms, but into the symbol systems and languages of art. Finally, it is argued that art has the capacity of emotional arousal contributing to greater retention of content as students give greater attention to content that they find exciting, curious, or interesting (Rinne, Gregory, Yarmolinskaya, & Hardiman, 2011).

Research has also demonstrated that arts integration programs are instrumental in stimulating students' emotional engagement. Emotional engagement is defined as student

attitudes and affective responses towards school and learning (Blumenfeld, Kempler, Krajcik, 2006, Fredricks, Blumenfeld, & Paris, 2004). Instructional practices which evoke positive emotional engagement such as a willingness to participate, interest, enthusiasm, curiosity, or a sense of intellectual wonder can be the precursor to cognitive engagement (Fredricks, 2014, Macklem, 2015). Strand's (2006) study of high school students who attended an arts integration summer camp found that students exhibited high levels of emotional engagement. Students were actively engaged in their projects throughout their class periods and returned after class to continue their work. Similarly, the students in DeMoss and Morris's (2002) study also had a real enthusiasm for their arts integrated project. This was evidenced by the willingness of extremely shy and retiring second language learners to participate in front of their classmates. The authors further observed that students engaged in out of class preparation as well as controlling inappropriate class behaviors. Arts integration programs were also found to stimulate emotional engagement and improve attitudes towards math in seventh grade students with learning disabilities, emotional/behavioral disabilities, and attention-deficit/hyperactivity disorder as seen in Anderson's (2015) study of the use of dance as part of math instruction. By the second week of the study, students in this study were willing to take leadership roles in choosing the music as well as leading the dance sequences.

Environmental Art education

Nature has long been the preferred subject of many famous works of art as artists have both reflected on its beauty as well as mirrored how the natural world is perceived and valued by humans (Weintraub, 2012). The environmental art movement was inspired by the environmentalism of the 1960s and the perception among artists that art should transcend the "nonrelational, noninteractive, nonparticipatory orientation" (Gablik, 1995, p. 80) of the modernist approach. Instead, Gablik argues that art should become an agent for social change and capture the public's attention through innovative and creative approaches to the realities of environmental problems. Environmental art thus became the "reverent relationship between the viewer and the earth" (Matilsky, 1992, p.37). Its artists sought to leverage their art to "inspire, advocate or innovate revealing and/or enhancing ecological relationships while modeling ecological values" (Wallen, 2012, p.234).

Environmental art education, a natural outgrowth of the environmental art movement, uses art to engage children in acquiring deep understandings and caring attitudes towards the environment. It is posited that learning about the complexities of the environment through art counters the traditional cognitivist, positivist approaches of science education. Instead it they are supplanted with the creative, affective and sensory approaches of art education (Inwood, 2008). Through artistic expression, children are able to develop ecological literacies involving interdependence, systems-thinking, biodiversity, conservation, and sustainability. At the same time, they are practicing problem-solving, critical thinking and communication skills (Inwood, 2008).

While research in environmental art education is somewhat sparse, there are some hopeful trends emanating from this area. One theme resounding through several of the studies was the power of environmental art to evoke feelings of empathy for nature. Bradshaw (2016), for example, conducted a qualitative study with middle school students documenting their reactions to an environmental art unit. After studying the work and perspectives of various environmental artists, students were tasked with creating environmental art that served as a

message about a social or ecological issue. Through their work, Bradshaw contends that students became more empathetic with each other as a result of working out issues within the project. Students also became more empathetic with the community and with the environment as they became advocates for their issue. In a similar vein, Weir (2016) found that students engaging in a variety of environmental art projects in her study developed deep connections to and empathy for nature and each other while developing ecological literacies. Weir attributes this to the power of art to engage students not only cognitively, but also emotionally as they visualize abstract ideas through an artistic lens. Bertling's (2015) students also progressed in their empathy towards the environment throughout a course where they investigated several environmental artists. In the Transformation unit, they visited a landfill and reflected on the amount of waste and how it could be repurposed. The final project in this unit was an art work made from waste. As they moved through the course, they developed greater ecological awareness and demonstrated a willingness to work for ecological change.

In a slightly different vein, Flowers, Carroll, Green, and Larson (2015) make the case for using art as a means of assessing student attitudes towards the environment and their sense of ecosystem complexity. Using a rubric adapted from the Draw an Environment rubric (Moseley, Desjean-Perrotta, and Utley 2010), the researchers were able to evaluate students' perceptions of the complexity of and affinity with the environment. In this project, students were prompted to draw an ecosystem with higher points given for pictures which demonstrated higher levels of eco-awareness and knowledge of interactions and relationships.

Place-based Education

The aim of place-based education is to "ground learning in local phenomena and students 'lived' experiences" (Smith, 2002, p. 586.). In place-based education, instruction is anchored in the resources of the local community for the purpose of enabling students to make connections to global issues. Dewey (1915) argued that most education is isolated from the students' everyday experience frustrating students who prefer actual experiences rather than synthetic conceptualizations. In place-based education, the conventional textbook is supplemented or even replaced by the living context in which the student lives. Through place based learning opportunities, students have greater connections to the neighborhoods in which they live and create greater relevance and applicability of the curriculum to their daily lives (Inwood, 2008). Typically, place-based education is experiential emphasizing learning which is "hands-on, project-based, and always related to something in the real world" (Veal and Wallace, 2011, p. 70).

Place-based education connects with a broad range of content areas and instructional designs but has particular relevance to science and nature studies (Smith 2002). When focused on developing ecological literacies, place-based education curriculum promotes a connectedness with the natural environment and builds deep environmental understandings and awareness (Lloyd & Gray, 2014). There have been increasing calls for place-based science education due to a variety of issues. Today's typical science textbook, for example, provides generic content suitable for a national mass market, but with little linkage to local ecosystems (Sobel, 2012). In addition, more and more children are losing contact with the natural environment as they play indoors either as a consequence of parental restrictions or engagement with electronic devices (Louv, 2005, Pyle, 2008). More importantly, while most school subjects decontextualize content, place-based learning in science emphasizes the importance of place. This gives students,

particularly marginalized and indigenous students, a sense of pride as well as agency as they seek to find solutions to local problems (Kuwahara, 2013). Working within a place-based curricular framework blends traditional science knowledge with local knowledge that is often ostracized in conventional science instruction creating richer, more meaningful understandings (Chinn, 2007). Finally, it is argued that "When people acquire a deep knowledge of a particular place, they begin to care about what happens to the landscape, creatures, and people in it" (Stone, 2009, p.13). Thus, studying their local ecosystem enables students to create an emotional bond with their environment leading to a more sustainable future (Louv, 2005, Sobel 1996).

The intersection of the visual arts with science focused place-based education creates opportunities not only to engage students cognitively but also to introduce new perspectives which engage them emotionally (Jacobson, McDuff, & Monroe, 2007). The intertwining pedagogies encourage students to pursue new connections and affinity with their place while building empathy for their native ecosystem and valuing its peculiarities (Bertling, 2015, Graham, 2009, Hansen, 2009). Artmaking becomes a tool which mediates understanding and enables to students to critically articulate their understandings about the place where they live (Muthersbaugh, Kern & Charvoz, 2014). The process of experiencing and interpreting their place through the arts creates meaning and relevance for students as it strengthens the relationship of learning and knowledge to the physical reality of that place (Higgins & Nicol 2002, Inwood, 2008)

The purpose of this study was to examine the contributions of the arts and augmented reality technology to an interdisciplinary project which integrated drawing and painting into place-based learning as means of acquiring knowledge of the native species and the food web in the Coastal Bend in South Texas. In particular, this study investigated student knowledge of Texas rattlesnakes and their importance to the ecosystem of South Texas. A mixed methods approach was employed for this project. Student learning was quantitatively assessed using drawings made before and after educational programs and were evaluated by a rubric. The impacts of this program on the students as witnessed by the teachers and parents in this school community were qualitatively assessed through a focus group and other data. The research questions guiding this study were:

1) Were there differences in learning about the ecosystem of Texas rattlesnakes as evidenced by a rubric assessment of pre and post drawings and paintings of Texas rattlesnakes in their habitats?
2) What were the impacts of the program on students as seen by their parents, teachers, and administrators.

METHODOLOGY

This study employed a mixed methods research design to investigate the contributions of the arts and augmented reality technology to student learning about trophic levels centered on Texas rattlesnakes in the Texas Coastal Bend. Mixed methods research offers the opportunity for deeper understandings of the phenomenon under study by drawing on the strengths of both qualitative and quantitative research. Quantitative data for this study was obtained through a pre-test and a post-test while qualitative data was obtained through conversations with focus groups.

Context

This study was situated in a small, rural, PK-8 public school district in South Texas that is located close to a regional university. This district has routinely received ratings of "Met Standard" from the Texas Education Agency based on four criteria: 1) student achievement, 2) student progress, 3) closing performance gaps and 4) postsecondary readiness. At least 87% of the district is Hispanic, and 71% of the district is classified as economically disadvantaged. The district is in a small town of fewer than 1,000 people and is surrounded by farmland.

Participants

This study included two groups of participants, the 4th and 5th grade students and a focus group of parents and teachers of those students. The student group included 33 4th graders and 27 5th graders distributed as seen in Table 1 (appendix).

A group of nine parents, teachers, and administrators took part in the focus group. Of the eight females and one male, there were teachers of the students, teachers who were also parents of the students, administrators who were parents, and parents. The parents who were not already teachers were invited by the school.

Data sources

Student drawings (pre and post) were assessed using a rubric developed by the researchers. This rubric was developed through a review of the literature and by examining other similar rubrics (Flowers, et al., 2015. Moseley, et al., 2010, Savvaidou-Kambouropoulou & Skoumios, 2012; Smith, Meehan, Enfield, & Castori, 2005; Wagoner & Jensen, 2010). The rubric in this study had four domains:

1) Picture shows features which are consistent with the South Texas habitat,
2) Picture shows a diversity of features including producers, consumers and nonliving things,
3) Picture shows diversity within producers, consumers and nonliving things and
4) Picture shows features in proper relationship (or scale) to each other.

Each domain was scored on a scale from 1 (lowest) to 5 (highest).

Qualitative data was drawn from multiple sources. Data was drawn from focus groups of parents, teachers, and administrators whose conversations were guided by a semi-structured interview protocol. Questions investigated students' perceptions of working with a wildlife scientist and artists and their perceived impacts on students' learning. Data was also drawn from reflections written by students regarding their initial pictures and video scripts done by students for their second pictures.

Procedures

This project was a collaborative effort among three researchers including an Art faculty, a Wildlife Science faculty and an Instructional Technology faculty. After receiving permission from the school, one of the researchers met with the classes during art period and asked students to draw a picture of a rattlesnake in its environment using colored pencils and paper. To clarify, what was in the drawings, students were asked to turn their paper over and briefly describe what was in the picture and what consumers and producers were present. Afterwards, the drawings were collected, and three Wildlife Science graduate students were trained on the rubric and

served as raters. After scoring a few sets, sample pictures were evaluated for interrater reliability. Each picture's scores from the sample set were averaged across all domains, and scores for the sample set of pictures were correlated among all graders. When the Wildlife graduate students achieved a significant correlation, they were released to grade the complete initial set.

The Wildlife faculty member visited 4th and 5th grade classes and gave a review on trophic levels using the western diamondback rattlesnake and other local species as examples. The following day students came to the university campus on a field trip to view live rattlesnakes at the serpentarium, tour a native plant garden, and participate in activities on the various flora and fauna in the rattlesnake food web delivered by the graduate students and the Wildlife Science faculty. Next, the Wildlife and Art faculty members went to the school campus and asked students to create a painting featuring a producer, a primary consumer, and a secondary consumer (specifically a snake) in South Texas. Students worked on their paintings with the Art faculty member and the school art teacher during their Art class over the next three weeks. They used acrylic paints, colored pencils and permanent markers on canvas.

After the paintings were completed, students created a script describing their paintings and met with the Technology faculty member who videoed each student delivering their script. The Technology faculty linked the video with the picture in Aurasma, an augmented reality app (www.aruasma.com). Augmented reality technologies layer digital information over the real world and, in this case, when the student's painting is scanned with a smart device, the video of the child describing his/her painting plays.

The paintings were collected and taken to the university where the same Wildlife graduate students applied the rubric and rated the new set. In order to clarify what they were seeing, each picture was accompanied by scripts from the video. Paintings were returned to the school for public art exhibits held both at the school and later at the university art gallery.

Data Analysis

According to Creswell and Plano (2017), data analysis in mixed methods research designs involves analyzing quantitative data using quantitative methods and qualitative data using qualitative methods. These authors further suggest that in analyzing mixed method data that the researchers follow the steps below.

- preparing the data for analysis,
- exploring the data,
- analyzing the data,
- representing the data analysis and
- validating the data analysis process

Below is a summary of the data analysis employed in this research.

Quantitative. Each picture (pre and post) was scored by the Wildlife graduate student raters according to the rubric. Scores for each student were then averaged yielding an average score per student for each rater. In order to assure interrater reliability, a Pearson's correlation was performed using each rater's set of scores by grade level to identify correlations among raters. Scores from the two raters with the most significant correlations were then averaged for an average score by student for the pre and post. A paired samples t-test was conducted to compare scores pre and post by grade level.

Qualitative. Qualitative data was collected from the participants using a parent and teacher focus group, descriptions of the initial pictures written by the students, and video scripts written by the students of the final painting.

A focus group moderated by two of the researchers was held with a convenience sample of teachers, administrators, and parents a short time after the school art exhibit. A semi-structured approach guided the conversation with follow-up questions asked by one of the researchers to clarify issues as they emerged. A verbatim audio-recording was made of the meeting, and a transcript was given to each of the researchers.

The researchers read through the transcripts, descriptions, and scripts, to become familiar with the content, concepts, and ideas. Transcripts, reflections, and scripts were examined for possible codes, and sections of the transcript were labeled according to their codes. Through an iterative process of reviewing the codes, relationships among the codes became clear which were further refined into three overarching themes: 1) excitement, interest, and curiosity, 2) enhancing learning, and 3) communication.

RESULTS

A paired samples t-test was conducted to compare the average score of each student's initial drawing with the average score of their final drawing as seen in Table 2 (Appendix). There was a significant difference in the average pre and post score for students in each grade level, 4^{th} grade $t(32) = -2.320$, $p = .027$, 5^{th} grade, $t(26) = -3.001$, $p = .000$.

In order to more deeply understand the impacts of this program on students, the faculty team examined the qualitative data through which three themes emerged.

Qualitative Themes

The qualitative analysis provided another perspective of the impacts of this project. Three broad themes emerged from the analysis. First, the parents and teachers described how real world connections and curiosity created engagement with the project. Second, the parents and teachers discussed the learning impacts that they had observed. Finally, the third theme, communication, emerged from the discussions of how the tools within this project created new ways for students to convey what they understood.

Interest.

Creating learning environments that capture student attention and nurture student interest and enthusiasm are key to promoting student engagement. While the topic of rattlesnakes was exciting; two other elements seem to have triggered student interest and the interest of their parents and teachers.

Real-world connections. This research was consistent with Veal and Wallace's (2011) recommendations that place based instruction should feature authentic learning experiences; but in addition, this research also introduced professionals in the field that enabled students to explore how the world is perceived by professionals outside of the school. This triggered interest, excitement, and lent added importance to the topic. One of the parents commented on the new perspective that working with the team from the university provided:

> ***** [my child] was very excited about it…..It's not the teacher talking about it; this is an adult out in the real world. Like this is something for them to look forward to…something they are interested in, some kind of a career.

This was echoed by another parent who said:

> Seeing someone from outside of school lets the kids know someone else is interested in this kind of stuff. That made a lot of the kiddos excited. You know really thinking about future careers.

Curiosity. Teachers and parents also expressed curiosity about the venom research that is conducted at the university and was discussed during the field trip. Several of the teachers and parents quizzed the Wildlife faculty about where the rattlesnakes were obtained, what the differences were between rattlesnakes, and how the venom that is extracted is used. One teacher noted at the conclusion of this conversation:

> That's cool. The rattlesnakes in our backyard are part of something bigger.

Impacts on Learning

This research also investigated parent and teachers' perceived impacts of the project on learning finding two perceived impacts.

Vocabulary. As students became involved in the project, the teachers noted that they began using the vocabulary associated with the food web. In fact, the art teacher said, "I, myself, had to do a little bit of research. Consumers….what are they?" One of the teachers who taught reading noted that the students were able to transfer their understanding of the food web to a story they were reading.

> When you came in, we happened to be doing a reading unit. Our topic was natural cycles. One of the stories that we read was about food chains. And it mentioned a snake, But, like she said, it wasn't in our backyard. It wasn't as specific. So, I think they had an idea, but it wasn't specific an example. They had an idea, but it wasn't specific to where they live. So as they were reading the story and hearing about the snake, they were applying the terms that they had learned like consumer, predator, prey, they were applying it to other animals in the story. I didn't even have to make the connection. They were already bringing it up themselves. I really noticed that after they learned those things and then they were reading about it. I think they enjoyed it more and were more interested because they were doing something that wasn't in my class. They got more from the story.

Detail. Focus group participants also commented on the detail that students reflected in their paintings. One teacher shared:

> When the students got to go to the Center and see the snakes up close in a safe environment. I am thinking that it helped their art because they were

> able to have an idea of the detail of the snake and then they could draw the snake… I think it gave them a better idea to use in their art because we saw some of them drawing snakes in like a striking position and like he said, looking angry. Some of them did look very angry. When we all saw them we said, "Ooooh, he looks like he is mad at us. Like he might strike us. " And some of them didn't really mind. They were just hanging out. I kind of saw both of those characteristics in the different pieces that the kids created. I think it was good for them to see it in real life instead of just looking at a picture or seeing a video.

A parent disclosed that for her child:

> He was talking about patterns and scales, and then being a consumer, he was using the words, and then he was so enthused about his picture that he created that he wanted us to come see it. He didn't take notice of the patterns before of the snake or scaling detail so when he saw his artwork; it had a pattern.

Communication

Augmented Reality. As students completed their paintings, they wrote scripts about their paintings which included a discussion of the elements of their drawing, the roles of the various animals in the paintings, and the materials that they used. Afterwards, the students were videoed, and the videos were connected with the paintings through an augmented reality app, Aurasma. When we asked the focus group participants about the augmented reality, one administrator shared, "It was the 'Wow' factor." Another teacher said,

> I know the students were really interested in it because they like technology, but it's not allowed to use their devices [at school]. So, when I think some of them were nervous about being recorded, but they were very excited to show their talent. They liked holding their devices and seeing their videos. I think they were really excited and interested in that.

Picture as Story. When students were describing their pictures for the video, several students did not just describe the elements in it, but the story that it told. For example, one student shared, "In my painting, you see a rattlesnake getting ready to strike a frog." Another student said, "In my picture, you see a diamondback rattlesnake with a mouse creeping up behind the rattlesnake." Yet another student said, "In my picture you see a snake preying on the bunny while the bunny eats a flower. The person [in the picture] was shocked about the snake."

DISCUSSION

The aim of this study was to evaluate student learning about rattlesnakes in the South Texas ecosystem as evidenced by pre and post drawings of rattlesnakes in their environment. Analysis of students' pre and post drawings did show a significant difference in their ability to represent the rattlesnake ecosystem and in particular consumers, producers, predators, and prey through art. Analysis of focus group comments shows that students were highly engaged, were

able to transfer their learning to new environments, and were able to communicate what they learned as story.

Several factors contributed to this being a highly engaging project. Learning environments that create relevance by situating instruction in real-world contexts and in particular in their own environment are of great interest to students (Inwood, 2008, Reschly & Christenson, 2012). In this project, not only were students learning about rattlesnakes as an exemplar of the South Texas ecosystem, but they also had a chance to view snake movements and body details at the serpentarium and local vegetation at the native plant garden. Further, exposing students to a broader range of career options and connecting their learning to the world of work also deepens engagement (Klerk, 2013). In this project, professionals in their fields were the leaders giving students a chance to interact with adults pursuing career paths that students may not have considered but have interests in. Finally, experiences that spark students' curiosity offer rich opportunities for student engagement. When teachers are curious, they foster these qualities in their students (Engel, 2013). The focus group participants expressed curiosity that the venom that was extracted at the serpentarium is used in research for medicinal purposes and gave them new respect for rattlesnakes. Creating engaging environments is of paramount importance as students who are highly engaged are more likely to learn at high levels with a deep understanding of what was learned, and greater satisfaction with their studies.

In the initial drawings, students could scarcely name a consumer or producer. After the project, nearly all of the students were significantly better able to identify the producers and consumers in their pictures. There are several reasons for these differences. First, this is consistent with Donovan and Pasquale's (2012) assertion that integrating art into instruction enables students to engage deeply, synthesize what they know and convey meaning through their art. Rinne, et al., (2011) express that the capacity of art to arouse emotion can also contribute to better recall. In addition, using artwork to quantitatively assess student's understanding of concepts is a novel approach in science, but one that shows great potential.

Additionally, Wyer, Schank, & Abelson (1995) argue that narrative is the default mode of human thought and serves as the basis for memory. It is said that the brain seeks patterns which create associations that are meaningful and relevant to what is already known (Roth & Jensen, 2011). The patterns within narrative (characters, plot, and sequence) offer a familiar template for making sense and communicating what we know about the world. In many of the videos, the students did not simply share the elements of their pictures but told stories. Thus, the pictures they created served as a powerful platform for depicting the story of food web relationships.

Another key to the success of this project is the intertwining of the philosophies of place-based environmental education with art. At the beginning of this project, most of the pictures the students drew did not situate the rattlesnakes in Texas ecosystems, much less the extended food web, despite the fact that rattlesnakes are found in the fields surrounding their school. In essence, the students failed to see the snakes as a part of their local environment. After their field trip and extended interactions with the wildlife scientists, time to work with the art professor, and time to process and reflect, the students' artwork more accurately reflected their local environment and relevant members of the food web.

LIMITATIONS AND FURTHER STUDY

The limitations of this study are largely related to the small sample size. The population of students in this study was located in a single, small, rural town in South Texas. Further, the

focus group sample was a purposive sample of teachers, parents, and administrators. Due to the size of the town and the district, the roles of the participants in the focus group overlapped which may have contributed to conflicting viewpoints. Future studies may investigate this same type of project in more urban locations and with different food webs.

CONCLUSION

Although place-based education and art education may seem like disparate approaches to science education, their integration in this project proved to create a powerful and meaningful learning environment for these students. Together, these approaches created a learning environment which was at once participatory and dynamic and encouraged students to observe an ecosystem in their local community as an example of ecosystems in the larger world. It also empowered students to connect to and experience their environment while developing a deeper understanding of how an often feared and hated part of the ecosystem, snakes, plays an important role.

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Appendix

Table 1.

Distribution of students by gender and grade

	Girls n, %	Boys n, %	Total
4th Grade	13, 39	20, 60	33
5th Grade	13, 48	14, 52	27

Table 2.

Paired samples t-test results for initial and final drawing comparison.

4th Grade	Mean	SD	5th Grade	Mean	SD
Initial	1.80	.53	Initial	1.94	.45

Final	2.09	.70	Final	2.74	.74