



Nature photography: a spark for discussion and action on environmental issues

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Abstract

Recent advancements in emerging technologies have changed how people go about their daily lives. These tools and platforms, for example, nature photography and citizen/community science projects, provide alternate methods for people to develop, retain, and disseminate information on various social, cultural, and political topics, such as environmental issues. These platforms also provide enormous potential for environmental educators to explore ways to increase student engagement, including their use in the outdoors. For this exploratory research study, we were guided by the following research question: In what ways, if any, can a nature photography activity in a summer environmental education program help spark students' discussions and actions regarding the environment and environmental issues? Data was collected from five upper elementary and middle school students who attended a week-long summer program in August 2022 focused on coastal ecology at a local nature center (Massachusetts, USA). Data collection included educator observation notes of students, nature photography student worksheets, student-taken photographs, parent feedback forms, students' end-of-the-day reflection entries, and student photographs for two citizen/community science projects. The findings suggest that (1) nature photography can help educators spark valuable discussion on the environment and environmental issues while engaging students in a hands-on outdoor activity, and (2) nature photography can help educators spark actions on the environment and environmental issues while engaging students in outdoor citizen/community science projects.

Keywords Nature photography · Student-centered learning · Environmental actions · Environmental discussions · Citizen/community science · Emerging technologies · Outdoor education

Recent advancements in emerging technologies have changed how people go about their daily lives. We have witnessed an explosion of various mobile devices, social media websites/applications, artificial intelligence-based chatbots, and other technological advancements (Hoi, 2020; Okonkwo & Ade-Ibijola, 2021). These technologies have provided alternate methods for people to develop, retain, and disseminate information on various social, cultural, and political topics, such as environmental issues (Hendriks et al., 2016). However, there is still much to learn about the ways in which these technologies can be employed in an educational setting.

In highlighting the roles of such communication technologies, Schäfer (2012) previously identified two potential groups that can be roughly described as “cyber-pessimists and cyber-optimists” (p. 528). The first group “cyber-pessimists” (Schäfer, 2012, p. 528), identifies those who see limitations and dangers in effectively using online and social media platforms for science communications. The second group Schäfer (2012) identifies as “cyber-optimists” (p. 528), such as those who see the rise of these online and social media platforms as a positive shift for science communication as a means to increase user engagement and understanding. For this qualitative research study, we provide evidence that engaging students in citizen/community science projects (Nugent et al., 2015; Phillips et al., 2019) in an outdoor setting via nature photography and social media platforms, which we refer to as emerging technologies (Rotolo et al., 2015), can help environmental educators to engage students in meaningful discussions and actions around environmental issues. Throughout this study, we view ourselves as “cyber-optimists” (Schäfer, 2012, p. 528).

The work in this paper identifies the importance of a shared space that exists between emerging technological tools and their use outdoors in the environmental education field. We were specifically interested in exploring a summer education program that utilizes these shared spaces to better understand students’ perspectives and experiences. Limited research is available on how students utilize nature photography as an opportunity to engage with emerging technologies and tools while outdoors. Photography-related activities in an educational program can allow students to experience instruction involving different disciplines (Cappello & Lafferty, 2015). For this exploratory research study (Maxwell, 2013; Oliveira et al., 2021), we were guided by the following research question: In what ways, if any, can a nature photography activity in a summer environmental education program help spark participants’ discussions and actions regarding the environment and environmental issues? In investigating this, we provide empirical evidence to help outdoor and environmental educators, communication specialists, policymakers, and other stakeholders understand more about this shared space.

Conceptual framework and review of relevant literature

Theoretical lens

Environmental education demands transformative content to help navigate society toward a more sustainable future (Ferreira, 2013). Ferreira (2013) argued in her study that environmental education should “empower individuals to transform themselves

into informed and active environmental citizens, thereby leading, it is assumed, to the transformation of the behaviour of whole communities and entire societies” (p. 63). The nature of transformative education generated in an environmental context requires rethinking our relationship as humans with our surroundings and planet, which includes realigning our existing worldviews (Pavlova, 2013).

For this research study, we refer to environmental education activities that utilize and build on examples and content that rely on the social perspectives of the community involved with a goal of transformation towards a sustainable society where all species in the natural world can co-exist, as sociotransformative. Rodriguez and Morrison (2019) argued that the sociotransformative approach is focused on participants and researchers working as collaborators to explore the issues the communities face, i.e., environmental issues for this research study perspective. This approach is grounded in concrete transformative actions, with the educator purposely working as a facilitator, inviting participants to share their experiences on the environmental issues their communities face.

For this study, we utilize emerging technology tools, such as nature photography and citizen/community science platforms (Nugent et al., 2015), to interact and engage students while teaching them about environmental content. We utilize nature photography tools to engage students in understanding the coastal environment they live in, i.e., the local beach and estuary. The goal was to encourage students to pay attention to the natural world around them, such as to understand that other species live on this planet and share it with us. As part of the ecosystem, our actions profoundly impact these species. The summer course explored the human impacts on coastal ecology for students through hands-on learning experiences. Students were prompted with questions about the photographs they took outdoors while participating in the week-long summer program. These questions resulted in various discussions and actions on environmental issues by the students. They focused on their day-to-day life experiences, familiar places, and issues they can experience themselves. We also utilized parents’/guardians’ feedback to understand students’ perspectives further.

The outdoor and environmental education field can benefit from a better understanding of emerging technologies and their various tools to enhance and increase public engagement in science communication and learning (Kumpu, 2022). Over the years, the science education community has shown a growing interest in understanding the roles of emerging technologies and science learning (Becker et al., 2020; Kalogiannakis & Papadakis, 2019; Lin et al., 2023; Oliveira et al., 2019). In the United States of America, the Next Generation Science Standards (NGSS) highlight emerging technologies as tools that open doors for new and improved scientific investigations for students (National Research Council (NRC), 2013). The NRC’s (2012) Framework for K-12 Science Education upon which NGSS was built highlighted that “together, advances in science, engineering, and technology can have—and indeed have had—profound effects on human society, in such areas as agriculture, transportation, health care, and communication, and on the natural environment” (p. 210). Providing students an opportunity to use such emerging technologies as part of their learning can benefit environmental and science education in general (NRC, 2012; NRC, 2013).

We framed this study while utilizing and building on the student-centered learning approach highlighted by Arif (2021) and Wright (2011). The student-centered approach is a way to actively involve students in their learning process, as students are in charge of what they want to learn, how they want to learn, and, most importantly, why they want to learn. This study utilizes a sociotransformative lens (Ferreira, 2013; Pavlova, 2013; Rodriguez & Morrison, 2019), which we believe is critical for any outdoor environmental education activity.

Conceptual framework

Our framework is divided into four major parts (see Fig. 1) that address the basic constructs of our study that, in an ideal world, would highlight the connection between emerging technologies (i.e., nature photography), student engagements (i.e., actions, discussions) and lastly, transformative student-centered learning (the center of our framework), through outdoor environmental education programs such as our nature photography activity. We utilized this framework to inform our understanding of different ways in which these constructs lead to overall student engagement when implemented in an outdoor environmental education program. This emergent conceptual framework was developed with a sociotransformative approach highlighting social issues identified by student and researcher collaborations.

The conceptual framework model begins with 1) Nature Photography as a driving force for engaging students in 4) Environmental Education. This is accomplished as (1) Nature Photography helps educators to (2) Spark Discussion on the environment

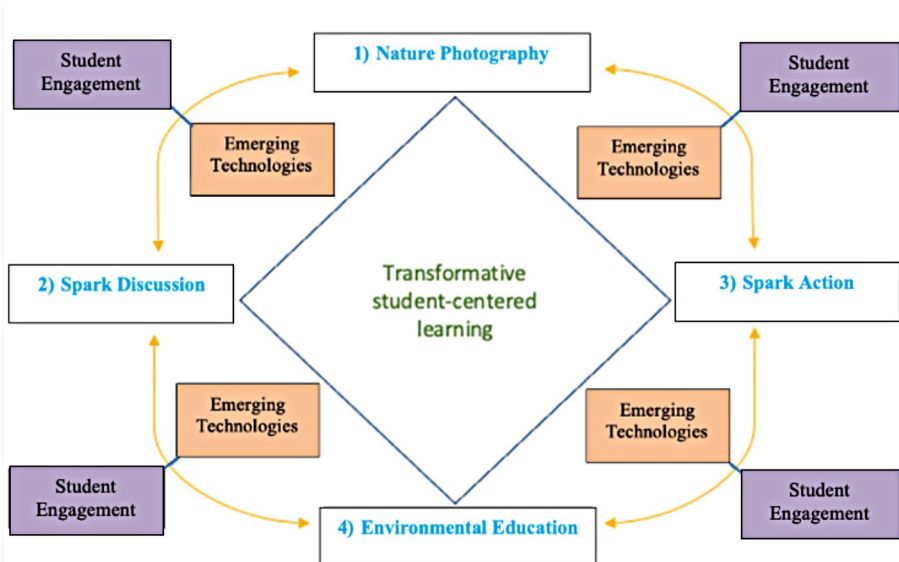


Fig. 1 Conceptual model. *Note* Our emergent conceptual model shows the circular relationship between environmental education and nature photography. While these individual constructs are numbered in our figure, these numbers do not imply a set sequence of actions. As the double-sided connecting arrows noted, the constructs build on and inform each other

and environmental issues with students. Utilizing student-taken photographs helps educators discuss environmental issues identified by the students or their pictures. Loeffler's (2004) work identifies that environmental education programs and photography tools, when utilized together, enhance student engagement, learning, and development of connections with the natural world, i.e., realigning existing world-views. Additionally, our framework highlights how 1) Nature Photography provides opportunities for educators to (3) Spark Action while collaborating with students to highlight different environmental issues and (4) Environmental Education. For environmental action within the context of this research study, educators utilized two citizen/community science project portals - the Shark Trust's The Great Eggcase Hunt (Shark Trust, 2023) and Morgan Stanley and National Geographic's Debris Tracker (Johnsen, 2023). Uploading pictures to these portals provides students with hands-on learning and engagement experiences with issues connected to their local environment. The four double-headed yellow arrows (in Fig. 1) highlight how emerging technologies, such as nature photography activities and citizen/community science platforms, inform each aspect of the emergent conceptual framework (i.e., student engagement with these emerging technologies). These constructs, viewed through the sociotransformative student-centered learning lens (Arif, 2021; Ferreira, 2013; Pavlova, 2013; Rodriguez & Morrison, 2019; Wright, 2011), helped frame this study.

Nature photography

When used effectively, photography can provide opportunities for students to learn about various topics and skill sets (Ardoin et al., 2014). Pictures, when used with thoughtful instruction, can allow students to visually gain some understanding of things that might not be possible for them to experience in their day-to-day lives (Byrnes & Wasik, 2009). For this research study, we focus on the pictures the students took when exploring their surroundings, which educators then utilized to spark discussion and action supportive of the environment and environmental issues.

While talking about the positive effects of learning in the natural environment, Dillon (2014) stated that there is "strong evidence for broadening science education pedagogy to include experiences beyond the classroom and laboratory" (p. 506). This study focused on understanding action and discussion instances beyond traditional "classroom" engagements. Engaging participants outdoors through photography has the opportunity to evoke emotions, feelings, memories, and experiences of those capturing the images (Morse et al., 2018). Cappello and Lafferty (2015) argued that photography has the potential to provide meaningful instruction across disciplines and can help connect people with nature (Barrable & Booth, 2020). For this research, we utilized nature photography as an emerging technology tool that helps spark student engagement through actions and discussions on environmental issues while exploring outdoor areas such as a maritime forest area, salt marsh, estuary, dunes, and a local beach.

Spark action and discussion

Merriam-Webster (2024) defines spark as a word that highlights a response filled with enthusiasm or is closely related to the word “activate.” For this research study, we define spark as a word that reflects an opportunity for the students to channel their understanding, thinking, and feelings related to the environment and environmental issues.

To engage students in meaningful actions and discussions, environmental educators often use both in-classroom and out-of-classroom contexts to allow students to learn about environmental issues. As Falk and Dierking (2010) have stated, “surely the best informed and most science-literate citizens are those who enjoy maximal benefits from both in-school and out-of-school science learning opportunities” (p. 493). In an in-class context, educators involve students in a traditional classroom setting, including chairs, dry-erase boards, projector screens, etc. In an out-of-classroom context, environmental educators can interact with students outdoors to provide a practical and hands-on approach to the same science concepts students are learning in their classroom. Rennie (2014) stated that an out-of-school setting tends to result in different learning outcomes for students with different life experiences. In-class and out-of-class settings allow educators to explore non-traditional teaching approaches, such as utilizing nature photography activities. To support this, Waliczek and Zajicek (1999) argued that “it has been reported that students tend to learn better when they are actively involved, and hands-on activities help to improve their acquisition of new knowledge, skills, and attitudes” (p. 180).

Using in-class and out-of-class contexts with nature photography and citizen/community science platforms allows educators to spark meaningful actions and discussions on environmental issues. Utilizing student-taken pictures helps educators understand what caught the attention of the students or what students were interested in (Ardoin et al., 2014), therefore expanding on a student-centered approach for environmental education program activities such as various citizen/community science projects (Dopico et al., 2017) that increase active collaborations between students and educators. The hope for the outdoor and environmental education field is that these immediate experiences and discussions spark future actions and discussions throughout students’ lives.

Environmental education

The foundational concepts of the modern environmental education field can be traced back to Aldo Leopold’s 1949 work highlighting the relationship between people and the environment (Carter & Simmons, 2010). His work initiated deeper conversations within the American community about environmental threats. Another key marker for the EE field was Rachel Carson’s 1962 inspirational book *Silent Spring*, which highlighted significant environmental issues and their impacts (Sisson, 2018). Her work helped the field of EE to gain momentum within the US as well as globally. A significant international landmark propelling the EE field forward was the first United Nations Conference on the Human Environment in Stockholm, Sweden, held in 1972 (Carter & Simmons, 2010). This conference specifically focused on identify-

ing the importance of educating the younger generation and adults about environmental education.

In 1969, Stapp shared their definition of EE as a field that is “aimed at producing a citizenry that is knowledgeable concerning the biophysical environment and its associated problems, aware of how to help solve these problems, and motivated to work toward their solution” (p. 34). It is known as one of the earliest working definitions of environmental education. One of the primary foci of environmental education is understanding the relationship between environmental education methods and individual and community-level environmental behaviors (O’Malley & Pierce, 2022; Wals et al., 2014).

We aim to add and support existing research that focuses on understanding various environmental education methods, i.e., summer programs, and their connection with emerging technologies, i.e., nature photography and citizen/community science projects, in helping educators spark meaningful actions and discussions on environmental issues with their students. Building from the extant research noted above, our work highlights the need for empirical-based findings to support the use and integration of communication technologies, such as nature photography, across outdoor and environmental education programs to have a better and well-informed community.

Methodology

Inquiry approaches – exploratory & photovoice

This study used exploratory inquiry (Maxwell, 2013) with a sociotransformative student-centered lens (Arif, 2021; Ferreira, 2013; Pavlova, 2013; Rodriguez & Morrison, 2019; Wright, 2011) as our primary approach. The exploratory approach helped us understand nature photography’s role in helping educators promote discussions and actions on environmental issues. At the same time, our analysis was also slightly informed by the photovoice approach to understanding how taking photos and uploading them on different forums encourages students to bring social change (Wilson et al., 2007) in their surroundings, such as actions on environmental issues.

Context & participants

The Lloyd Center for the Environment (LCE) is a Southeastern Massachusetts non-profit organization whose mission includes environmental research, education, and outreach (LCE, n.d.). The center is on 82 acres of land containing a maritime forest, salt marshes, an estuary, an outdoor learning pavilion, and two indoor classrooms with various live exhibits (i.e., fish and touch tanks). The LCE hosts programming for students of all ages utilizing out-of-school and outdoor settings. In addition, the education staff serve as science content experts through sustained formal in-school programming in multiple districts throughout the school year (Stronach et al., 2023). Additionally, LCE offers summer programs annually for students ages six to twelve. From 2017 to 2021, LCE offered 35 overarching education programs catering to approximately 47,250 students of all ages from several major cities and towns in

Massachusetts (Malik et al., 2023). Data were collected from the five upper elementary and middle school students (see Table 1) who attended a week-long summer program at LCE focused on coastal ecology in August 2022. All students names are pseudonyms.

To align with our student-centered approach, we utilized several data sources to develop introductory participant profiles using data from our registration forms, guest speaker notes, and student self-reflection about their liking and preferences. The timing of each session was 9:00 am to 3:00 pm. The summer course addressed the importance of coastal biodiversity, habitats, estuaries, salt marshes, and human impacts on the environment. Some activities were based in an in-classroom setting. However, most activities occurred outside the nature center and at a nearby beach/estuary.

Students were given individual point-and-shoot cameras for the whole week, and each content topic had a photography component embedded. Participants had an introductory nature photography workshop on the second day of the course. The nature photography workshop was divided into three parts. The first part started with a PowerPoint presentation to share tips and techniques for taking better pictures in the field. The presentation included various local and international context-related pictures. Students were given hands-on training on how to operate their cameras. The second part included an hour-long trail walk throughout the Lloyd Center's property for the students to complete their photography worksheets. The third part asked students to complete a worksheet to reflect on their progress and provide information on one picture they liked the most by providing a short rationale. The nature photography worksheet included information for students to take context-specific photographs and asked them if they had taken at least ten pictures as a part of their activity.

Data collection and analysis

Data collection followed guidelines from Maxwell (2013) and Oliveira et al. (2021) to include educator-student observation notes as the primary data source. Other data sources include nature photography student worksheets, student-taken photographs, parent/guardian feedback forms, students' end-of-the-day reflection entries (AHA! Journals), and student entries in citizen/community science projects. Observation data were analyzed following guidelines from Creswell and Poth (2018), emphasizing that qualitative researchers must focus on understanding and relying on participants' points of view of the given situation to establish themes and patterns. We

Table 1 Participants' information - name (pseudonym), grade level, gender, and age

Participants (pseudonyms)	Grade Level	Gender	Age
Arcee	4	Not Specified	10
Bumble	5	Male	11
Jazz	4	Male	9
Slash	5	Female	10
Wind	3	Female	9

Note The five participants registered for the free-choice program through an application submitted by a parent/guardian

utilized direct quotes from the students, their worksheets, and parent feedback forms to develop our initial assertions.

Photovoice analysis (Chanse et al., 2017; Sutton-Brown, 2014) was conducted to understand students' perspectives on environmental actions. Utilizing photovoice allowed us to reflect on participants' understanding of social problems, such as environmental issues – which is the focus of this research study. Our initial coding only included evidence that supported student discussion instances from our summer program. However, we quickly realized that engaging students with various photography activities also sparked environmental actions from the participants. This triggered a reevaluation of our coding process, to cast a broader net inclusive of instances that determine how these environmental actions were happening, utilizing photographs with two citizen/community science projects. All three researchers reviewed data that supported our shared assertions. Any differences among researchers were resolved with group discussions until a consensus was reached. This helped us ensure trustworthiness using different data sources, methods, and investigators, as Schwandt et al.'s (2007) work highlighted.

Our final coding process combined photography to explore participants' hands-on experiences (i.e., nature photography activity), discussions, and action instances (student to student, student with educator, student with their parents, two citizen/community science project entries), providing researchers with an improved understanding of our participants' perspectives on environmental issues. All five participants completed the nature photography activity and submitted photo entries for two citizen/community projects aligned with the overall coastal ecology course and student-centered perspective.

We also wanted to understand how nature photography operates as an emerging technology tool that allows students to engage actively with such citizen/community science platforms. We utilized Strauss and Corbin's (1998) constant comparative analysis to include documents, observations, and artifacts connecting it with the constructs in our conceptual framework.

Findings and discussion

The findings are organized into two sections reflective of the overall themes that emerged from the study: (1) Nature photography can help educators spark valuable discussions on the environment and environmental issues, and (2) Nature photography can help educators spark actions supportive of the environment and environmental issues. Each section has embedded assertions with supporting excerpts from multiple data sources. Throughout this section, we discuss how our findings are situated within the existing literature.

Nature photography can help educators spark valuable discussions about the environment and environmental issues

Our first assertion is that engaging students in nature photography within a summer environmental education program can help educators spark valuable discussions

about the environment and environmental issues by utilizing a hands-on outdoor activity. As part of the nature photography workshop, students were introduced to various tips and techniques to take better pictures. All five participants completed their primary task of taking at least ten pictures. Students were also tasked with taking context-specific pictures as part of this activity, for example, highlighting lines, shades, and textures in nature. All five students engaged in meaningful discussions with the educators or their classmates throughout the activity.

Students shared pictures that initiated discussions in a way that did not need much facilitation from the educators at the start. For example, our participant, Slash, shared a picture of a bird with Wind and Bumble, and as a part of this interaction, Wind also shared their picture with Slash and talked about whether they captured the same bird or a different one. Later, they involved one of the educators in their discussion, which allowed the educator to talk about different coastal birds, their habitats, and bird field marks to streamline easy bird identification for these students. Educators also utilized the bird photograph to show field marks to other students in the group.

The idea of asking students to take context-specific pictures was to provide a platform for educators to spark discussions on the topics that directly caught students' attention. To further engage students in an active discussion with the educators, we prompted our participants to choose one picture they wished to receive as a printed copy. Students were encouraged to explain the reasoning behind their selection process. We utilized the picture selection process to engage students in one-to-one or group discussions on the environment and environmental issues related to their selected pictures. Figures 2 and 3 showcase two participants' worksheets (Wind & Slash), which include their reasoning for the printed copy selection.

Wind (Fig. 2) chose her picture because she wanted her parents to see the shrimp she caught, and Slash (Fig. 3) chose her picture because she had never seen a leaf with spots like that before. Students developed fish traps using recycled plastic bottles as part of the estuaries and watershed unit. Wind's fish trap included multiple shrimp. She took a picture (see Fig. 4) and wanted to show it to her parents. LCE's educators utilized this opportunity to spark discussion with Wind about various scientific facts about the shrimp, such as their natural habitat, food, adaptations, and connection to the overall issues of coastal ecology.

Slash took a picture (see Fig. 5) of a plant with spots on it during the nature photography activity walk around the LCE's property. Once she took the picture, she directly approached the educator to ask questions about the plant. Educators leveraged this instance to teach Slash about various plants found at LCE's maritime forest area, prompting Slash with discussion on topics such as how plants get their energy (photosynthesis), when it gets cold in the area, how these plants survive, what kind of adaptations do these plants have and what are the overall impacts on coastal ecology.

The selection of these pictures allowed the educator to spark meaningful discussions with the students about the underlying science and environmental content related to their photo content. Students mentioned that they would be sharing these pictures with their friends and family members. On the evaluation form, Wind's parents shared that "this has been the first summer camp that [Wind] came home and told us everything she learned that day at the camp." We argue that Wind's reasoning for showing this picture to her parents opens a space for her to discuss with her par-

Nature Photography Activity Sheet

Dates: August 9th 2022Program: Coastal EcologyStudent Name: WindDid you individually take 10 pictures (at least) using the tips and techniques discussed? yes.*Please check the box to show the completed task.*

- Action shot (i.e., a bird or any kind of animal - observe & explore)-----☒
- Macro shot with a reference (remember the fish picture!)-----☒
- Any issues covering sustainability (i.e., plastic bags in the woods!)-----☒
- Textures, shades, and lines (leaf, flowers, etc.)-----☒
- Dimensions and perspective (i.e., docks, salt marsh)-----☒

I chose picture number 402 as my favorite to get a printed copy. I
 chose this picture because I want my
parents to see my shrimp.

Fig. 2 Wind's nature photography worksheet. *Note* Wind took all five context-specific pictures

ents and family what she is learning about the environment or related issues, ideally resulting in better-informed science communication. One of Slash's parents observed that "[Slash] would always talk about the program and how much fun she had. I like this program because it teaches them a lot."

Additional evidence supporting our assertion included students' entries for their "AHA! Journal." The goal of these daily end-of-the-day journal entries was to provide students with a chance to list up to three exciting things in a bullet format or a single paragraph highlighting what their "AHA" moment of the day was and, lastly, what might be something they want to continue to learn more about during the course timeline. Arcee and Bumble listed nature photography as one of the most

Nature Photography Activity Sheet

Dates: August 9th 2022Program: Coastal Ecology

Student Name:

Slash

Did you individually take 10 pictures (at least) using the tips and techniques discussed? yes but

I did not like

Please check the box to show the completed task.

- Action shot (i.e., a bird or any kind of animal - observe & explore)-----☒
- Macro shot with a reference (remember the fish picture!)-----☐
- Any issues covering sustainability (i.e., plastic bags in the woods!)-----☐
- Textures, shades, and lines (leaf, flowers, etc.)-----☒
- Dimensions and perspective (i.e., docks, salt marsh)-----☒

I chose picture number 0064 as my favorite to get a printed copy. I

chose this picture because the leaf had spots and I have never seen one like that

Fig. 3 Slash's Nature photography worksheet. *Note* Slash completed taking at least ten pictures for this activity

exciting activities for the day. Arcee's parents reported that "on the ride home every day, [Arcee] would tell me what she did that day and what she learned." All five participants explicitly listed nature photography as one of their highlights (AHA! moment) from the day's learning. As environmental educators, we felt compelled to engage students in discussions about the importance of documenting the trash via photographs and sparking action by collecting and removing it from the beach. This included discussion about the source of the trash (plastic single-use bottles, fishing gear gone overboard, etc.) and how to prevent these from entering the environment. NRC (2013) and NRC (2012) outlined the importance of students participating effectively in scientific practices and discourse, such as sparking discussion and actions,

Fig. 4 Wind's selected picture.
Note Wind took this picture to show her parents that she caught so many shrimp in her plastic bottle fish trap



Fig. 5 Slash's selected picture.
Note Slash was very engaged when she took this picture of the plant with different textures and shades



as one of the four strands to define proficiency in science learning. Participation in citizen/community science projects allowed students to participate *as scientists* in real-time scientific practices and discourses (Phillips et al., 2019).

Our evidence showed that engaging students in an outdoor nature photography activity can help educators spark valuable discussions about the environment and environmental issues.

Nature photography can help educators spark actions supportive of the environment and environmental issues

Our second assertion is that by utilizing nature photography, educators can spark valuable action that is supportive of the environment and environmental issues while focusing on different citizen/community science projects. During the week, as part of the coastal ecology summer program, students took a field trip to a local beach. Students participated in two citizen/community science projects: The Shark Trust's The Great Eggcase Hunt (Shark Trust, 2023) and Morgan Stanley and National Geographic's Debris Tracker (Johnsen, 2023), which the educator selected as a part of coastal ecology course objectives. Educators also utilized this opportunity to introduce citizen/community science as a field to their students (Nugent et al., 2015; Phillips et al., 2019).

At the start of the activities, students were briefed about the citizen/community science projects they would engage in. Educators also highlighted how uploading

pictures to these forums would help scientists learn more about the environment and environmental issues. “You are all scientists today!” one of the educators declared. The goal was to give students a sense of participation in real-world scientific projects. All five student participants were actively engaged as citizen scientists by utilizing nature photography. For the Debris tracker project (Johnsen, 2023), students were asked to take pictures of the trash they found at the beach. Each entry was directly uploaded to the citizen/community science portal in real-time by one of the instructors. In addition, we also carried physical trash bags and buckets to complete the beach clean-up process, which we identify as one of the core examples of sparking environmental action. These photographs of debris sparked action on the part of the students as they not only documented the trash on the beach but collected and removed it from the beach. Examples of the pictures students took while conducting beach clean-up are shown in Figs. 6 and 7.

Data entries in the Debris Tracker project yielded results of our field effort, as shown in Figs. 8 and 9. These figures and facts were shared with the participants at the end of the activity to spark discussions on what kind of trash was mainly found on the beach area, what the human impacts related to this trash were, what sources generated this trash, and lastly, how our actions today help scientists to figure out best solutions for such problems.

Students were engaged and excited to hear that scientists in the field would utilize their work. We observed that all five students participated actively as citizen scientists and were highly engaged. Jazz claimed this to be “the best field trip of my life,”; while Arcee asked, “Why do people leave this trash on the beach?” This question provided an opportunity for the educator to spark meaningful discussion focused on

Fig. 6 Bumble’s picture for debris tracker app. *Note* Bumble’s picture entry shows a broken lighter on the beach



Fig. 7 Jazz's picture for debris tracker app. *Note* Jazz's picture entry shows a styrofoam piece on the beach

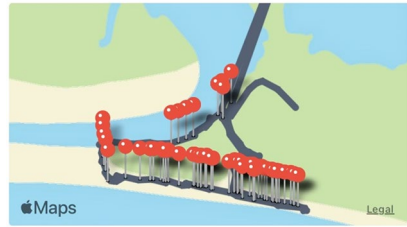


Fig. 8 Breakdown of trash items collected. *Note* This screenshot from the debris tracker app (Morgan Stanley and National Geographic's Debris Tracker, Johnsen, 2023) shows the breakdown of the items collected from the beach area



Fig. 9 Morgan Stanley and National Geographic's debris tracker (Johnsen, 2023). *Note* This screenshot from the debris tracker app (Morgan Stanley and National Geographic's Debris Tracker, Johnsen, 2023) shows the location pointers where each item was collected and photographed

Tracked for NOAA Marine
Debris
August 10, 2022 at 10:18 am



90 items collected over 2.68
km

action. One of the educators responded to Arcee's comment by proposing that, "now that you have cleaned up the beach yourself, next time you go to a nature area with your friends and family, make sure you are disposing your trash in a proper way and asking everyone in group to do it as well." Educators successfully made visible connections for Arcee in a way that sparked a self-reflection and transformative response to dispose of their trash correctly the next time they are out in nature. This also connects to Pavlova's (2013) take on environmental education programs' engagement in a transformational context as to "...interrupt current patterns of power and power relations, and contributes to a reimagining of existing worldviews, including a reconsideration of the relationships between people and planet" (p. 660). A meaningful action opportunity is developed once educators successfully connect students with their local environmental issues utilizing pictures that they took themselves, focusing on highlighting how they, as individuals, can make a difference.

This discussion emphasizes the importance of sparking immediate action (beach clean-up activity) and planting seeds in the students' thinking to spark future action throughout their lives – an essential goal of environmental education. In fact, in the days that followed the beach clean-up activity, the students, unprompted by the educators, continued to clean up trash they found on the trails and beaches visited on subsequent days during the workshop. It became clear to us that the photography and citizen/community science activities that the students were engaged in sparked not only immediate action but also future action on subsequent days. Figure 10 shows the trash the students collected during their field trip, demonstrating the efforts of their actions during the beach clean-up.

For the second citizen/community science project, students were tasked to find shark and ray egg cases for the Great Eggcase Hunt project (Shark Trust, 2023). The primary goal of this project was to collect data for scientists to understand shark and ray populations, distributions, habitats, and other features. Figures 11 and 12 show students' entry pictures shared on the citizen/community science portal.

All five participants found multiple egg cases on the beach area, which prompted various environmental conversations with the instructors. As citizen/community scientists, the students contributed data about sharks and rays that would help the scientific community understand their distribution. Recall that this action was sparked by

Fig. 10 All 90 items collected, photographed, and properly disposed. *Note* This image shows all the 90 items collected and photographed for the clean-up activity



Fig. 11 Wind's entry picture. *Note* Wind's photo entry for the Shark Trust's The Great Eggcase Hunt



Fig. 12 Slash's entry picture. *Note* Slash's photo entry for the Shark Trust's The Great Eggcase Hunt

teaching students about nature photography and how taking photographs and uploading them to citizen/community science databases can make a real difference. Our finding suggests that these students operated as “Cyber-Optimists,” as Schäfer (2012) highlighted, which means they can potentially utilize online and social media platforms to improve science communication when they share these pictures with their friends and family. Our findings are similar to Barrable and Booth's (2020) study, which presented a positive relationship of using technology to enhance participants'

connections with nature. In our case, they used citizen/community science projects to share their pictures with the scientists working in the field.

We also wanted to acknowledge that engaging students in these projects sparked scientific discussions. For example, when Jazz was collecting the egg cases, she asked one of the educators, “Is there any chance it [egg case] hasn’t been used?” to which the educator responded, “The egg case is like an eggshell that is formed when the animal is developing.” The other educator added that “there is a very rare chance for us to see a unused egg case on the beach area.” This interaction provided us with an example of how students were not just uploading their photo entries for the citizen/community projects to complete their tasks. However, more than this, they were engaged in meaningful discussions that we believe support the possibility of meaningful future actions. Such discussions included educators prompting students to think about how cleaner beaches mean less trash will end up in the ocean, hence protecting natural habitats for sharks and rays.

All of the pictures taken during the course were available for the students to utilize for their educational or personal use. Dekoninck and Schmuck (2022) noted in their study that people who promote issues such as sustainability and climate change using online platforms tend to cause an increase in offline participation of people who are connected to them, such as their friends, family, and followers. Involving students in citizen/community science projects also helps educators foster the importance of collaboration in better understanding environmental issues while working with other students and educators (Dopico et al., 2017; Phillips et al., 2019).

Student participation in such activities supports our assertion that such work sparks positive and real-life actions that are supportive of the environment and environmental issues. We hope participating in such activities will also prompt students to actively upload pictures on different citizen/community science projects in the future, suggesting that nature photography can offer a productive tool to engage students in emerging technology platforms such as citizen/community science projects (Nugent et al., 2015).

Conclusion

As environmental educators, we must focus on understanding the nexus of environmental education and emerging technology tools to empower the “transformative content” (Ferreira, 2013) that nurtures pro-environmental communities. Students’ participation is higher in programs providing hands-on experiences, here outdoor experiences, that support opportunities to take charge of their learning (Arif, 2021; Wright, 2011), primarily about environmental issues (Malik et al., 2023).

This study has been our attempt to investigate instances we recorded during our coastal ecology summer course that yielded various student discussions and actions related to environmental issues. Our empirically based findings support experts’ opinions about the positive impact of emerging technology tools for enhanced science learning (Oliveira et al., 2019). Pictures from our participants, Wind, Slash, Jazz, and Bumble, and AHA! Journal entries highlight examples of students utilizing nature photography tools to enrich their science learning experiences.

Educators utilized nature photography as a method for the students to take pictures of the real-time environmental issues they identified as participants in citizen/community science projects. We argue that nature photography workshops help educators spark discussions about environmental issues beyond traditional classroom-type settings, thus being inclusive of outdoor settings. Educators can focus on highlighting issues identified by the students in their photographs (Ardoin et al., 2014). Such out-of-classroom interaction allows educators to engage students in a hands-on experience where they can observe these issues in real time rather than vicariously.

We also provide evidence that nature photography as a tool has great potential to be utilized by teachers to involve students with citizen/community science projects that spark actions on environmental issues, such as environmental pollution, conservation efforts, and species diversity. All five participants completed two citizen/community science projects (Shark Trust, 2023; Johnsen, 2023) they were involved in that directly related to these environmental issues. Students were provided with an introduction regarding how scientists in the field would utilize the data from this activity. This increased students' motivation and excitement about participating in these projects. Educators also utilized this opportunity to have an open discussion with students about how they can individually make changes in their lifestyles that can minimize these impacts on the environment in the future, making this activity transformative.

This is also an example of sparking future action on the part of the students. Rodriguez and Morrison (2019) noted that for science education researchers to make a sustainable change in our community, we must highlight our participants' lived experiences. This research study aimed to empower students to take ownership of their learning experiences while generating meaningful content using nature photography. These pictures allowed us to directly observe what was catching students' attention or topics they were interested in. Jazz described this as "the best field trip of my life," highlighting the impact of these experiences on students. Wind's parents mentioned how glad they were when "she [Wind] engaged herself and asked to come back next year." In addition, Jazz's parents relayed how they would "hear *all* about the activities of the day every day! Experiments and hands on activities ROCKED! *He [Jazz] loved it !!! Thank you!*," they added.

More research studies are needed to explore the roles of new communication technologies involving nature photography, citizen/community science projects, and others, especially from a student-centered perspective. Such studies should focus on understanding how students use such technologies when given an opportunity while learning science in different contexts, such as in-school and out-of-school settings (Hillmayr et al., 2020; Rodriguez & Morrison, 2019). There is also a need and opportunity for policy and practice experts to develop more student-friendly online platforms (i.e., citizen/community science projects) that can help spark more actions and discussions supportive of the environment and environmental issues. Based on our findings, we encourage others to explore ways to inculcate various emerging technologies in their programs to enhance students' science learning experiences and improve environmental and outdoor education. Doing so allows us to explore the new shared space between emerging technologies and the education field from a

student-centered perspective and increase students' interest in science learning in general.

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Data availability The data that supports the findings of this study are not openly available due to reasons of sensitivity and are available from the corresponding author upon reasonable request.

Declarations

Competing interests The authors report no competing interest to declare.

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