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Middle school science teachers' agency to implement place-based education curricula about local wildlife

Diane S. Wright[a,b], Kevin R. Crooks[a,c], Don O. Hunter[d], Caroline E. Krumm[d] and Meena M. Balgopal[a,b]

[a]Graduate Degree Program in Ecology, Colorado State University, Fort Collins, Colorado, USA; [b]Department of Biology, Colorado State University, Fort Collins, CO, USA; [c]Department of Fish, Wildlife, and Conservation Biology, Colorado State University, Fort Collins, Colorado, USA; [d]Rocky Mountain Cat Conservancy, Fort Collins, Colorado, USA

ABSTRACT

Environmental education researchers and policy makers acknowledge the need to act responsibly toward the environment. Yet, teachers do not always know how to help students translate environmental knowledge into sustainable action. This study examines the implementation of locally developed place-based education (PBE) curriculum for middle school science classes with the intention of promoting environmentally positive behaviors. Camera traps were placed near schools and teachers were provided with photographic data of urban wildlife to use during ecology lessons Through our grounded theory study, we found that teachers who perceived a curricular alignment and drew on curricular agency were willing to adopt and adapt the lessons for their classrooms. Those who did not implement the lessons either lacked curricular agency or perceived a misalignment of the PBE lessons and their school context. Our study informs environmental education professional development leaders, who, we argue, should allow teachers to first explore their own curricular agency and context. In addition, we encourage educators to explore how PBE can create opportunities to teach students about civic engagement.

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There has been a recent growth and interest in the field of urban ecology (Forman 2014; Soulsbury and White 2015), a particularly relevant topic for K-12 students to explore because lessons can often be adapted to be locally relevant. Place-based education (PBE) uses the local context as a starting point to teach students about interconnected social-ecological systems with intentions to encourage civic engagement (Woodhouse and Knapp 2000; Smith 2002; Gruenewald 2003b; Sobel 2004). However, PBE is more. It can increase both environmental and civic literacy, where literacy is defined as having both content knowledge about a topic (i.e. the environment and civics) and the ability to apply that knowledge to answer questions and take actions related to that topic (Roberts and Bybee 2014). Furthermore, because time spent outdoors as children is directly associated with increased environmental literacy, it makes sense for environmental educators to explore strategies to help teachers engage youth in outdoor activities (Pitman et al. 2018). Therefore, increasing engagement with and understanding of the local natural environment through outdoor activities can increase a person's connection to and sense of belonging in that place (Semken and Freeman 2008; Kudryavtsev, Krasny, et al. 2012).

CONTACT Meena M. Balgopal Meena.Balgopal@colostate.edu Department of Biology, Colorado State University, Campus Delivery 1878, Fort Collins, CO 80523-1878, USA.

Understanding the local environment includes not only knowing about natural areas but examining how local social structures can impact community and individual behaviors in such areas. Although teachers may be receptive to implementing PBE curricula, if they have insufficient experience creating, observing, or participating in lessons, they may not feel prepared to teach using this approach. This paper explores how middle school teachers in one community made decisions about using PBE lessons designed around urban ecology.

Place based education

Connecting natural and social systems allows teachers to guide interdisciplinary learning (Gruenewald 2003a); however, PBE is inconsistently defined across research studies. Smith (2002) focused solely on *place,* whereas Greenwood (2008) viewed PBE as a critical pedagogy for decolonization. Bowers (2008) argued that PBE should rely on intergenerational knowledge to incorporate historical and cultural aspects of place. Kudryavtsev, Krasny, et al. (2012) and Ardoin (2006) claimed that the development of a *sense of place* (e.g. a connection to place through place attachment and place meaning) in PBE should be front and center. More recently, Cruz, Selby, and Durham (2018) advocated for a funds of knowledge and social capital approach to PBE, drawing on the cultural and personal knowledge learners bring to lessons. Others argue that the use of local resources requires the engagement of and collaboration between schools and community organizations thereby developing numerous connections among community members (Nagel 1996). We adapted and integrated definitions described by Woodhouse and Knapp (2000), Gruenewald (2003a), and Smith and Sobel (2010). In our research, we define PBE lessons as those that: (1) are inspired by local cultural or biophysical context or issue, (2) allow school and community organizations or experts to collaborate, (3) integrate interdisciplinary content, (4) use inquiry and experiential pedagogy, and (5) are designed to encourage civic engagement.

The primary value of PBE is to strengthen a person's connection to the people and places in which they live and to promote local civic engagement. Potential outcomes of the strengthened connection provide benefits to both people and natural places. People may experience (1) improved livelihoods, (2) a change in behaviors that favor conservation strategies, (3) increased civic engagement, (4) positive change in local economics, or (5) increased pride in being a part of the local area (Gruenewald and Smith 2014; Dale et al. 2020). The bio-physical environment may experience (1) recovery from previous ecosystem degradation, (2) increases in biodiversity, or (3) sustainable use of ecosystem services (Smith 2007).

Scholars argue that PBE develops inquiry skills, values clarification, and reinforces problem solving (Knapp 1985; Gruenewald 2003b). Not only does PBE prepare students to become informed citizens it prompts them to examine issues and make thoughtful choices that have multidimensional effects on the social and natural environment (Knapp 1985, 2005; Flanagan and Gallay 2014; Gallay et al. 2016). Because of the exploration of social issues when studying ecological topics, Smith (2007) and Greenwood (2008) argued that PBE is a form of critical pedagogy offering opportunities for learners to engage with issues of race, gender, class, and culture. Hence, PBE pushes teachers and students to critically examine how use of and changes to natural areas affects community groups, including themselves. The numerous benefits of PBE, including increased student desire for learning (Ernst and Monroe 2004) and attachment to the broader community (Flanagan et al. 2019), are well recognized (Smith 2002; Gruenewald and Smith 2008).

In spite of the depth and breadth of research on PBE and how it benefits students, including how it impacts their environmental and civic literacy, why and how teachers choose to use PBE in their classroom is understudied and undertheorized. Of the few studies that examine teachers' decisions about implementing PBE, findings focus on teachers' structural reasons (like administrative support or weather) for inconsistent implementation (e.g. Linnemanstons and Jordan

2017; Miller and Twum 2017). However, there is a rich literature that examines the complex reasons around teachers' pedagogical decisions (e.g. Roehrig and Kruse 2005; Tao and Gao 2017; Woodbury and Gess-Newsome 2002). Our goals were to more deeply investigate teacher use of PBE lessons beyond solely structural reasons. We examined how middle school science teachers made sense of and implemented PBE curricular resources as they addressed academic standards related to ecology to increase environmental literacy of their students. Recognizing that adoption, adaptation, or rejection of PBE materials by teachers can be influenced by their agency in a particular context (Balgopal 2020), we used teacher agency as a framework to design our study and analyze the findings.

Theoretical framework

Teacher agency

When teachers are able to actively contribute to the design of curricula, they exhibit agency in shaping the conditions of their classroom (Beista et al. 2015). Agency consists of different yet simultaneous orientations or elements toward shaping the actions teachers take (Emirbayer and Mische 1998). The first element is *iterational*; teacher thinking is influenced by past personal and professional history. The second element, *projective*, describes how teachers look toward possible future benefits, while the third element is how the teacher engages with the *present*. As teachers think about their practices in the classroom, all three elements of agency influence decisions on whether or not to take action. Teacher agency can be developed and shaped by both extrinsic (e.g. mentors) and intrinsic (e.g. psychological resilience) variables (Balgopal 2020). When teachers capitalize on their personal and contextual resources, they have the power to take control of their situation and solve problems, prompting Biesta and Tedder (2007) to purport that people achieve, rather than have, agency. Therefore, to study agency, it behooves researchers to identify what variables influence teachers as they make curricular decisions about environmental concepts and whether these decisions are driven by external factors or by teachers themselves (Spence, Wright, and Castleden 2013).

Research on teacher agency is informed by social cognitive theory, which describes learning as a largely social process based on observing others (Bandura 1997; Sullivan et al. 2012). Teachers develop skills through collaborative learning and observation of master teachers, then attempt to implement the skills in their own classroom (Sullivan et al. 2012). When a teaching style demonstrates positive results for students, it is more likely to be repeated. Teachers draw on both intrinsic (personal) and extrinsic (structural/ cultural) variables that shape their beliefs and subsequent behaviors in the classroom (Woodbury and Gess-Newsome 2002). However, these variables alone do not explain why some individuals may be motivated or not to change behaviors, as when making choices about what and how to teach science (Addy and Blanchard 2010; Furtak 2012; Spence, Wright, and Castleden 2013).

The following question informed our study: What factors influence middle school science teachers to adapt their instructional approaches to implement PBE lessons on urban ecology?

Methods

Both constructivist and sociocultural research orientations assume that human behavior is affected by surrounding social and cultural factors (Guba and Lincoln 1994; Lee 2012). In other words, personal experiences and structural/cultural contexts influence how teachers think about curriculum and instruction and their subsequent choices as teachers (Woodbury and Gess-Newsome 2002). Teacher beliefs alone, however, do not determine their thinking about changes in their practice (Balgopal 2020). The elements of past experiences and potential future

trajectories also play a role in teachers' beliefs as they determine the level of effort needed to take action. This constructivist grounded theory study was designed to understand how middle school teachers in one district chose to adopt, adapt, or reject PBE curriculum. The five tenets of the Chicago School of grounded theory call on researchers to 1) establish trust with participants, 2) focus on many forms of communication, 3) document how people communicate, 4) maintain sensitivity to how meaning is ascribed to objects and terms, and 5) describe how terms and symbols are used in communication (Charmaz 2005). We established trust with teachers through prolonged engagement, leveraging the relationship that the first author had with the teachers and school district as a perceived colleague. This position also helped our research team develop an in-depth understanding of the institutional context of the teachers, the policies to which teachers adhered, and school demographics.

Context

Beginning in Fall 2017, a collaboration was established between Riverside School District (RSD, a pseudonym) middle school science teachers, university researchers, and a non-profit conservation organization dedicated to protection of wildlife in the western US mountain region to use wildlife camera traps located near schools to learn about local urban wildlife. Camera traps are an increasingly popular tool to survey wildlife populations as they are low-cost, non-invasive, and highly effective (O'Connell, Nichols, and Karanth 2011). They are used in wildlife research to provide unambiguous evidence of species occurrences that are easily identifiable and permanently available for use (Kays 2016; Nugent 2017). A professor of wildlife and conservation biology acquired additional funds to support teachers (Research Experience for Teachers) as part of a federal grant to study urban wildlife interactions. Through these funds, teachers were provided cameras, compensation for time and effort for participation, and funding to cover substitute teachers in order to attend professional development workshops focused on learning about a PBE approach to pedagogy and implementation of ecology curriculum. The non-profit organization, with the support of RSD teachers, developed a PBE curriculum, including lesson activities and assessments to help teachers incorporate the photographic data generated by the cameras into classroom learning. All of the public school teachers who participated in this study were expected by their schools to adhere to standards-based lessons. Therefore, the PBE lessons were aligned with the national Next Generations Science Standards (NGSS Lead States, 2013) that were developed in the U.S. to help states define their own academic standards. Lessons prompted students to monitor wildlife in their school "backyards" while sparking discussion about human-wildlife interactions and conservation efforts. Open-ended inquiry questions about ecological phenomena including using photographic data from camera traps prompted students to ask questions, search for patterns, and draw conclusions about local urban wildlife. Professional development workshops were held four times and covered topics such as using a camera trap, data organization, writing to learn to make sense of photographic data, place-based education components, and ideas for middle school student civic engagement about local natural areas. Each workshop also included time for teachers to share ideas on using the data with their students. All workshop content was aligned with Next Generation Science Performance Expectations for Middle School Life Science (Appendix A). This study was considered ethical and was approved by both Colorado State University and School District Institutional Review Boards (protocol 329-18H).

Curriculum

The co-created PBE curriculum designed by teachers and the non-profit organization centered on the big question "What can we learn from a picture?" and aligned with NGSS performance expectations for middle school for life science (Appendix A). The curriculum storyline included inquiries using the photographic data to draw conclusions from what is seen and not seen in the photographs to

determine local food webs and energy transfer through the ecosystem. Having photographic data from multiple sites provided the opportunity to compare the urban wildlife present across RSD. A map of camera locations led students to consider human impacts on natural environments. Teachers were provided digital access to the PBE curriculum and encouraged to modify the lessons to meet the needs of their student population. The curriculum outline can be viewed in Appendix B.

Participants

All science teachers from 12 middle schools in RSD were recruited to participate in this project. Ultimately, 11 teachers from 10 schools chose to participate. They were asked to place a remote wildlife camera in natural areas on or near school property with support of the non-profit organization in gaining permissions and purchasing hardware and consider how they might use the picture data in their teaching. One teacher had previously used camera traps personally and in the classroom while all the others were new to the technology. Participant experience ranged from first year teaching to 28 years of experience (Appendix C). Site-based management in RSD allows for each school community to determine a school focus to meet the needs of students within that attendance area. Class length is also determined by each school and in accordance with state requirements. Class sizes vary based on student population size and schedules. All names presented are pseudonyms.

Data collection

The first author spent 60 hours observing, interviewing (both formally and informally) participants, and reviewing curricular artifacts including lesson plans, presentations and student handouts that participants shared with us. Participants were observed as they were implementing PBE lessons either in classrooms or outdoors on field trips near their respective schools. All observations were recorded as field notes. As with grounded theory studies, interviews were the primary data source and observational fieldnotes and analysis of curricular materials were used to triangulate findings. Twelve hours of interviews were recorded and transcribed for analysis.

With the support of the non-profit organization in placing and maintaining cameras, the cameras were functional from Fall 2017 to Winter 2019 generating photographic data of wildlife (e.g. bobcats, coyotes, red foxes, raccoons, and deer) for teachers to access and use in their PBE lessons. Over that time, participating teachers were interviewed using a semi-structured interview protocol (Appendix D) for an average total time of 60 min per teacher. An initial interview allowed the first author to reconnect with teacher participants with whom she had previously worked as the RSD Science Curriculum Facilitator to inquire about pedagogical practices and desired involvement in the camera trap project. In the second year of the project, a follow-up interview focused on the implementation of the five PBE components using the camera data. Each teacher was observed at least two times, either in their classroom teaching the PBE lessons or while on outdoor excursions to camera locations. During observations, parts of lessons were either video recorded or documented in detailed field notes. In addition, teachers shared their instructional artifacts (handouts, assessments) with us. The data were organized for each teacher, along with their demographic information, allowing us to develop cases for analysis.

Data analysis

Interview and artifact data collected during multiple interviews and observations were transcribed. Initial open coding occurred using an iterative process. We initially identified patterns following methods described by Charmaz (2020), who advocated for the use of sensitizing concepts to help "open inquiry rather than to mold it into a previously established theoretical framework" (168). Open codes included background, identity, academic standards, and school

structure as examples. These open codes were then collapsed into four axial codes: reflective practice, reflexive practice, instructional context, and classroom context.

Subsequent coding occurred by identifying intrinsic and extrinsic variables described by participants using RQDA software (Charmaz 2020). Selective codes included agency and alignment. We recognized that teachers' instructional choices are influenced by their intrinsic (e.g. personal) and extrinsic (e.g. structural and cultural) contexts, so teachers' comments about why or how they chose to implement PBE lessons were organized into these contextual categories. (Woodbury and Gess-Newsome 2002). The data were then reanalyzed with a focus on participant connections to the environment and to education, which were collapsed into themes of how the data described teacher practices and contexts (Appendix E). The first set of interviews and codes were used to inform subsequent interviews, observations, and artifact collection. From these, final propositions were determined.

Trustworthiness

To establish trustworthiness and reduce bias in the study, two authors (DSW and MMB) co-coded 20% of the same interview transcripts, and the first author coded artifacts. In the process, research questions were revised as the code book was clarified. After a period of time, the data were reviewed for potential re-coding as part of an iterative process to establish intra-rater reliability (Creswell and Poth 2016; Creswell and Creswell 2017). Once transcription for the second set of interviews was complete, an inter-rater coder was trained and analyzed 20% of the transcripts. The inter-rater reliability was 80% and all discrepant codes were discussed and clarified until full agreement was met. The findings were shared with a group of teacher educator research peers through a process of peer debriefing. Although the debriefing did not result in revising our codes, it challenged us to ensure that our claims were supported with evidence. Once transcripts were coded, we used data triangulation to ensure that our final codes could be supported by other sources of data (curricular artifacts, observational notes, and videos of lessons). Teacher lesson plans demonstrated opportunities to collaborate with community experts while student notebooks indicated action items for harmonious human-wildlife coexistence.

Positionality

The first author has been a K-12 teacher and teacher educator for the past 26 years. She worked in district elementary and middle schools for five years and was the district science curriculum facilitator for six years in the school district in which this study took place. As a science classroom teacher, the first author sought opportunities to connect content to real-world scenarios to enhance student understanding beginning with local contexts then expanding out to a global view. She has continued to participate in social and professional gatherings with teachers in the district, and in this way, we assumed she had built trust with the participants of this study. The last author is a former secondary science teacher and science teacher educator, having taught science methods and/or leading pedagogy workshops for the past 15 years. During this time, she has been studying environmental education and PBE, and recently has been conducting work in the Global South using UNESCO's Education for Sustainable Development framework. Subsequent authors provided grant funding and project support to teacher participants. The other co-authors all have extensive experience using camera traps and engaging with the public (i.e. speaking on public radio, giving community presentations, collaborating with educators) about urban wildlife issues.

Findings

Based on their decisions to implement the components of PBE while using the camera trap photographs and curriculum, we classified teachers into four categories: *implementer, partial implementer, non-implementer, and non-responder* (Table 1). Categories were defined based on the presence or absence of (1) teacher-perceived instructional and class context *alignment* and (2) teacher *agency* over their own curricular choices (Figure 1). Alignment refers to academic standards (i.e. instructional context) and classroom structure. Academic standards drive the curricular content a teacher chooses to implement in their classroom followed by methods for teaching that content. For example, all participants taught about the flow of energy in ecosystems through food chains and food webs. Teachers identified as implementers chose to incorporate data from the local camera traps whereas, partial and non-implementers continued to use previous materials. Teachers who chose to use the accompanying urban wildlife curriculum saw a direct connection between academic standards, the content of the photographs, and how to use them with students to advance environmental literacy. A teacher's level of agency influenced whether or not and to what degree they chose to specifically use the PBE camera

Table 1. Place-based education characteristics. Middle school science teachers incorporated the five components of PBE differently in relationship to their implementer status.

Place-based education characteristics			
Characteristic	Implementer	Partial Implementer	Non-implementer
Local context	Yes	Yes	Yes
Experiential	Yes	Yes	Yes
Collaborate with local experts	Yes	Yes	Yes
Interdisciplinary	Yes	No	No
Civic engagement	Yes	No	No

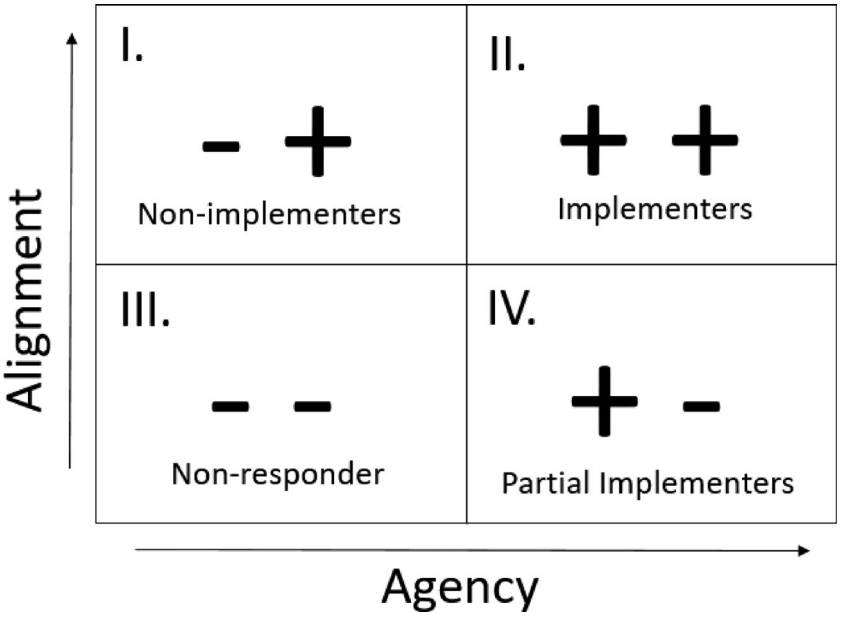

Figure 1. Model for curriculum implementation. Alignment is represented on the y-axis and agency on the x-axis and presence (+) and absence (-) of these constructs is indicated. In quadrant II, teachers were implementers of the PBE curriculum. In quadrant IV, teachers were partial implementers and demonstrated curricular agency but could not find curricular alignment. In quadrant I, non-implementers recognized curricular alignment but did not achieve agency. In quadrant III non-responders may been interested in PBE curriculum but did not participate.

trap curricula. The teachers who achieved curricular agency were able to be reflective and reflexive in drawing on background experiences that elevated their curiosity about their local natural environment. They felt their local natural and social environment was relevant for students to learn content, connect with community partners, and become thoughtful and engaged citizens.

Implementing the curriculum involved adopting or adapting the provided materials. All participants were receptive to examining new PBE curriculum materials aligned with academic standards. Teachers believed the camera trap photographs would provide a valuable experience for students to investigate the local environment and wildlife across the city while introducing students to technologies used by wildlife ecologists. Teachers saw the lessons as an opportunity for students to analyze authentic data from a familiar context. Additionally, all participants felt they were supported by their administrators and peers, although to different degrees.

Implementers: Beth, Michelle, JoAnne

Implementers not only demonstrated agency to use PBE in their classroom, they recognized the alignment with what they were expected to teach (standards) and how (class structure). All three teachers expressed comfort with taking risks and embracing PBE as a part of how all science is taught. They all had had (iterative) experience being innovative without fear of unknown outcomes. For example, Michelle chose to use her school's location next to a river to teach students scientific observation techniques and as a location for the school's camera trap. Based on positive feedback from students, she expanded her use of the local environment throughout the school year and supported the development of a school-wide "River Week." Implementers described future benefits (projective) for themselves and their students by learning how to ask and investigate questions that cannot be answered within the time frame of one class period or curriculum unit. They also recognized the potential (projective) benefits of reaching out to the community.

Beth was motivated to implement PBE strategies using the data based on prior experience with camera traps both at a previous school and on family property; she saw the potential in using authentic data to help her students learn ecology. Hence, she achieved curricular agency by recalling past experiences, informing her current decisions, with intentions about future implementations.

> "My family now is very into the cameras too… And now for Mother's Day we're putting a couple in my grandma's [farm]…and she lives right by the river, so we know she gets deer and coyotes and turkeys, and we've got a couple really good paths, so we're gonna set up a couple cameras to see what we can see."

Past experiences at successfully using camera trap technology allowed Beth to manage uncertainty that arises with using an open-ended curriculum and demonstrating the ability to reflect iteratively on past decisions. Additionally, during one observation and interview session, Beth encouraged students to wonder about the collected camera data from cameras placed near the school and from former school cameras and develop questions that future camera data may help answer. Reflecting on the past, she demonstrated curricular agency in the present. She was aware of the (projective) potential future benefits for students as they considered bigger PBE questions together.

> "… I said this is being used for actual research purposes, guys, so you can start making a difference now, and if you're really into this that can be a job path for you. I think it's helping them have a broader view of the impacts that they could be having on the place [her emphasis] where they're living."

Although Beth did not indicate how her students could be civically engaged, she continued to reference phrases, such as "*do stuff in real life,*" throughout her interviews and classroom instruction. As an example of how the camera trap data could be used for research purposes,

Beth referenced honors thesis projects being conducted by undergraduate students using the camera locations and photographic data. Similarly, Michelle believed that experience collecting scientific data can help students become better scientists and understand how data can be used to manage natural areas. They both continually referenced the past, the present, and the future as they made curricular decisions about PBE. As a past participant in Research Experience for Teacher programs in Africa and Alaska (the northernmost US state), Michelle knows that…

> "…This is what I did when I was doing my research and here's my results and data tables and logbooks, and I want them to see that this is what scientists do."

Here, Michelle illustrates her strong belief in experiential science education. Michelle went on to describe her approach to teaching science mixed with her own understanding of the goals of PBE while teaching about the environment. *"I'm a firm believer in getting kids outside doing field research…it's how science works – learning, reflecting, asking new questions…part of it for our kids is getting outside and realizing what's out there and how it's our responsibility to take care of the environment."*

Furthermore, Michelle explained the importance of teaching her students skills to be active community members and understanding their local environment. She referenced not only the curricular approach that her school followed (IB curriculum focuses on developing critical thinking skills while exploring issues from a global perspective; Tarc 2009), but also the belief that only when students experience their environment are they aware of and concerned about environmental issues. Subsequent observations of Michelle's classroom took place at the river within walking distance of the school and in a local state park where students took part in activities to learn about the local environment and participate in a project to control non-native plant life. As she shared her thoughts about PBE, she spoke about connecting present experiences with future dispositions of her students, reflecting her own perceptions about her experiences as a teacher.

> "…I feel if we want to keep our kids civically engaged in their community and their environment, they need to know what it is and they need to care about it…if we can get kids outside and caring about their environment and becoming educated about their environment so when they see things in the news and they hear things, they're aware of what that means."

As a teacher who was originally stifled by the camera location barrier in the first year of the project, JoAnne was motivated to use camera trap data and used the professional development workshops as an opportunity to collaborate with peers in the district by engaging in conversations with Michelle and Roger about their experiences using the photographic data. In the second year of the camera trap program JoAnn moved the camera to a different location. She was able to overcome initial personal (knowing how to collect the data) and structural (logistics of asking students to collect the data) barriers of using a new technology, demonstrating how she achieved agency. She referenced the past and a perceived barrier, and then shared how she overcame the obstacle in the present. In her second year, she demonstrated confidence and enthusiasm in the data and shared this with her students.

> "The last time I looked at the data, the kids were all working on something and I was just flipping through [wildlife pictures] and I was like 'oh guys look at this' and showed a couple of them, it sparked a little something in there, I think it's easy to spark kids interest in it, because it's a wildlife camera."

This sparked the design of an integrated science and math lesson using the camera data from three schools to examine environmental factors and graph data on frequency of occurrences of different organisms. She then asked her students to draw conclusions about data collected from a single camera compared to those from multiple cameras. She designed an open assessment for which students designed their own ecosystem which she was excited to explain:

> "We had podcasts, skits, built dioramas, and models [of ecosystems]. Like I had a girl… she did a Russian nesting doll, and on the outside, the biggest thing was the tertiary consumer, and the secondary consumer was inside that, and she had made clay models of each of them, and they were totally made up, like this [organism] has fangs and this one digs into the ground to do something, it was so, so creative"

JoAnne did not compromise her expectations of locally relevant ecosystem content knowledge, though, as she continued her description of one of her students.

> "…But she still showed that she knew that there was a flow of energy and a cycle of matter, but the way she did it was so cool. And she was the only one who included the sun, … the sun was the middle of her Russian nesting doll…that one blew me away!"

By taking the risk to let students demonstrate learning in a way that allowed them to be creative, JoAnn sparked her students' creativity. Furthermore, JoAnne garnered support from her administrator, further providing a context in which she could achieve and demonstrate curricular agency to adopt and adapt PBE curriculum when she reflected on the value of sharing successes.

> "When I was telling our principal about this project, I was so excited, like they're gonna invent ecosystems and they're gonna show it however they want, and he's like, that sounds really cool, because he's never said no….So that was kinda scary for me, but as long as I can see what you (the student) knows about ecosystems., We still had a rubric, we still had success criteria'

Because implementers recognized the alignment with instructional and curricular goals and demonstrated agency to not only adopt but to adapt PBE curricula, they were able to fully embrace all five components of PBE using the camera trap curriculum. Their students studied local wildlife,

Figure 2. Community civic engagement. An example of a place-based education civic engagement outcome is participation in a community art exhibit at the local shopping mall where students are able to visually demonstrate the co-existence of humans and wildlife.

collaborated with other teachers and wildlife experts, participated in experiential lessons, made interdisciplinary connections, and included community engagement experiences. A culminating event after the PBE unit was to create public announcement posters that were displayed at the local shopping mall to educate the public about the wildlife living in the community (Figure 2).

Partial implementers: Roger, Anna, Teresa

Teachers who were partial implementers achieved agency to design and implement their own curriculum for their classroom but, due to misalignments with curriculum or class structure, they did not fully implement PBE (Figure 1, quadrant IV). They demonstrated comfort with using new inquiry curricula and expressed personal connections or curiosity about the natural environment. Partial implementers asked students to collect data from camera traps and discussed the wildlife in the area. The data were used in the classroom but not in ways that extended beyond the school environment. None of these teachers referenced past experiences that would have influenced their perception of either adopting new curricula or engaging in PBE professional development (Priestley et al. 2012). They did not demonstrate that they were reflexive of their past teaching experiences but did consider action for future experiences (Ryan and Bourke 2013), hindering their abilities to achieve agency. We found that only the full implementers demonstrated both alignment and agency, whereas in the "partial implementor" group, alignment was missing. Although Roger demonstrated agency, the academic standards that drove his curriculum did not include those related to ecology. He chose to use the camera data as a way to engage students during an Extended Learning Period.

> "Generally, we go out there [to the camera] and we explore the area then because here we are blessed with more property than anywhere else in the district, and we're also in that urban rural interface with a wildlife corridor."

Roger capitalized on using the location of the school to prompt his students to observe the environmental context around their school. He wanted his students to feel a connection to their community yet could not fully implement PBE using the camera trap data since it did not meet his curricular goals, even though he was comfortable with the camera trap technology.

Teresa described her participation in the camera trap project as "*a great opportunity for me so I've been able to revise my [ecology] curriculum and [PBE] approach without waiting a year, so it's a great experience for me as a new teacher.*" She saw the potential in using photographic data to teach students about local issues and the nature of science. "*I have huge dreams for this database and the power that could come from the data. I would want to make it a regular routine of checking the camera because it's good scientific practice of following that protocol, collecting that data in the same way, standardizing information and procedures.*"

She discussed her own feelings about sustainability in her work. "*I think creating that personal connection with [students]…that's the key. Conservation action is about creating that personal connection.*" Teresa referenced her graduate program in Advanced Science Inquiry. She used her curricular agency to draw on her experiences to modify curriculum in ways that enhanced learning for her current students with goals of increasing their future environmental literacy.

She spoke about projective potential, even though the PBE lessons did not align with her teaching context. The barrier preventing Teresa from being a full implementer of PBE was the class structure at her school. The class she taught was an Environmental Science elective that met for 50 min once a week. In the middle of the spring semester, Teresa was informed that the school would not be offering Environmental Science the following year. In spite of the personal drive to implement PBE in her classroom, lack of contact time with students only allowed for partial implementation.

Similar to Teresa, Anna was in "*a very unique school [in RSD], we're a hybrid school, which means that our students sometimes work online and sometimes they're here on campus doing traditional*

classes." Being the only middle school science teacher at her school, Anna chose to design course curriculum for her classroom drawing on

> "…collaboration with people outside our school…I am the middle school science department here. It's great we have connections to other schools to find out what they're doing as well. But primarily I look at the [ecology academic] standards, what the students need to learn at the age they're at and design the [PBE] curriculum around that."

She was able to "*look at what my students have done online and change what I want to do in a live class, because either they didn't get it, or they did get it*." Also, Anna took advantage of the school building's location to implement the urban wildlife PBE lessons.

> "Our location, it's great. It's exciting that we have [a creek] right here…And this camera study will be a perfect way to get the kids down and engaged, and the fact that we have a wildlife corridor blocks from our school but we're right on the major busy street in this city, so I thought it was a great way to utilize our neighborhood."

Although Anna has the resources and mindset to be an implementer and spoke in projective terms about how the curriculum could impact learners' understanding of urban ecosystems, she was unable to fully implement the PBE curriculum because of structural context - her students studied in hybrid courses. First, "*some people really struggle with the online if you don't have time management, or if you don't have a learning coach, an adult who can help you, it can be a struggle to complete that independently*." Second, the student population *"fluctuates a lot. We get transfers mid-semester, both ways [in and out]*." This results in having to review material rather than going deeper or moving forward with content.

Non-implementers: Megan, Jessica, and Melissa, Carla, & CiCi

Non-implementers perceived the alignment of the PBE camera trap project with their curriculum and class structure but lacked agency to use the data in their classroom. Some of the non-implementers (Megan and Jessica) demonstrated alignment but no agency. They did not draw on experiences that they created for themselves to be reflective and reflexive. Although they attended multiple professional development workshops designed to provide collaboration time with local urban wildlife/camera trap experts, curriculum design experts, and peers, they still failed to be active implementers.

Both Megan and Jessica placed value on the experience using data collected by the cameras and the potential it could provide students to connect science learning with their local natural area. Megan felt students would be able to make "*actual real-world connections*" while Jessica envisioned "*so many different ways that we can use the data and pictures*." These non-implementers expressed personal interest in the project and curriculum yet discussed the use of it as something happening in the future. *"I definitely want to be doing that next year,"* Megan said. Similarly, Jessica explained: *"Last semester I was really involved with writing (camera trap) curriculum and sadly because I was writing it and spending my time on that, I wasn't using the curriculum as much in my science class last semester."*

Megan, who wanted to use the camera traps and data as part of an after-school ecology club, experienced difficulty navigating the procedures for taking students off school property, *"I'm still kinda hazy what the rules are with the permission slips."* With a constantly changing group of students, she was unsure how to ensure all students had permission to go outside on various

dates throughout the year. These non-implementers saw the potential in using the data as a way to engage students in learning about the local environment but did not have the agency to implement its use in the classroom at the time of the study, although neither described administrators as barriers.

The second group of non-implementers (Melissa, Carla, and Cici) did not use the wildlife camera trap project professional development workshops or curriculum. Although the idea of using local photographic data to teach about ecology interested them, they were not willing to put the effort into overcoming perceived barriers with technology, data management, or organizing a large number of students to visit the camera trap to change their current curriculum plans.

Melissa could see the potential of having locally relevant data, as she described below:

> "I think it'd be really great to have access to that authentic data, so instead of teaching ecology from a formulaic perspective, that this animal eats that and such and such, that you could actually have some real numbers…"

However, she was unsure of how to get the large number of students she and her science grade-level peers shared to visit the camera site, which they never determined.

> "Field trips are out for us… we're so large and the bus schedules are so tight. We would have to do a field trip between 9:30am and 1:30pm. We have about 380 students. And every teacher wants time with their students, so missing out on content, so it's really transportation limits us to getting off campus."

Interestingly, Melissa did not consider collecting the data on her own (retrieving the memory card from the camera trap) or responding to email messages to develop a collaboration with community members (e.g. university wildlife student) to help, so her students could analyze data in the classroom. CiCi had seen another teacher partner with a local expert on a previous camera trap project in a location more than 30 min-drive away from the school. She implied that the effort of collaborating with a community member was too time and energy consuming, and therefore, not worth it for her.

> "She was working with another guy [who] had his own organization…[and] he was helping with that whole thing. … But that was crazy, she was always driving down there and doing all that stuff…, it was too much, too teacher intensive and not localized enough."

It was not clear what would be more "localized" in CiCi's opinion; she did not elaborate. It was clear that she was not interested in the effort of collecting camera trap data, whether it was by herself or with a community partner.

Meanwhile, Carla was curious about how to manage large amounts of data. *"One of the questions I had for the photos in the Dropbox: if I had 1000 pictures, how do I upload all of them?"* Here, Carla could not imagine how to organize a large data set, even though it would represent authentic, locally relevant data for her students to analyze. Carla decided to not participate in the project, demonstrating she was unable to reflect on past experiences to determine how to overcome perceived barriers. Although Carla was a teacher who might consider using camera trap PBE lessons, if she had more professional development on data management and analysis. She did not express concerns about the technological aspects per se.

Non-responsive

Non-responsive teachers did not participate in professional development opportunities and never replied to invitations to be interviewed to explain their perspective and perceptions.

Discussion

Although there is potential to increase students' environmental and civic literacy through the use of place-based education curricula, we found that middle school teachers need support to help them identify the alignment of lessons with their professional expectations as well as agency to adapt lessons, so they are meaningful for their students. Teachers who perceived a curricular alignment and demonstrated curricular agency implemented the PBE curriculum presented to them (Table 1). They were able to address academic standards using local examples with support from local wildlife experts, incorporate an interdisciplinary approach, and investigate potential avenues for civic engagement. Partial and non-implementers either perceived a misalignment or lacked agency to integrate the camera trap curriculum in their ecology units or in other content areas at deep levels (e.g. promoting civic involvement). Instead, these teachers focused primarily on ecological information transfer, while the implementing teachers interconnected knowledge across content areas and encouraged students to take action in the community using evidence they collected about urban wildlife.

PBE is designed to increase K-12 students' environmental literacy skills, while encouraging them to be active community members as they develop better understanding of local social and biophysical ecosystems (McInerney, Smyth, and Down 2011; Sobel 2004). This is particularly relevant because people demonstrate a range of conceptions of how humans are a part of and affect ecosystems (Casper and Balgopal 2018). However, teachers need to feel prepared to support their students if they are to implement a PBE curriculum. The teachers in our study demonstrated a range of involvement in PBE instruction based on their ability to perceive how to integrate the lessons into their existing curricular framework and their experience in doing so. Because teachers who can act purposefully within their work environment and continue to learn from past perceived barriers demonstrate agency, we conclude that this attribute may explain when teachers choose to implement PBE lessons or not, since an interest in environmental education is not enough to determine which teachers will adopt environmental education curricula (Spence, Wright, and Castleden 2013).

Successful curriculum propagation includes designers understanding potential adopters (teachers) and their instructional system (school, district, and academic standards), as well as designers engaging with potential users for input prior to presenting a finished curriculum (Stanford et al. 2017). Because the first author had previously been employed by RSD, she held an initial understanding of district structures to navigate in order for teachers to use a new curriculum. For PBE curricular reform to occur, teachers need to feel comfortable and willing to adapt the curriculum for their educational context (Henderson et al. 2015; Roehrig and Kruse 2005). Yet, preceding this comfort level is having had the experience and support to modify curricula, demonstrating curricular agency, (Priestley et al. 2012; Tao and Gao 2017). When teachers are able to draw on their curricular agency to meet the needs of students, their use of adapted curricular resources are more likely to be sustained (Balgopal 2020; Khatri et al. 2016). For example, at one teacher professional development workshop, JoAnn, who had not used any of the curriculum or photographs at the time, asked "what do you want me to do?" The reply from the workshop facilitator was an invitation to design lessons that are meaningful to her students using wildlife data to teach about urban ecological systems. After conferring with other teachers, JoAnn eventually designed an integrated math and science project that she continues to use. This study presents a model, informed by teacher agency, that describes when teachers adopt, adapt, or do not use PBE lessons.

To advance environmental literacy in the classroom teachers need to help students make the connection between social and ecological systems and between ecological and community well-being. Educators need practical instructional strategies to bring these connections to fruition to help their students become environmentally literate and engaged citizens. For example, in this study, teachers who implemented PBE lessons assisted their students in engaging and

educating their community about urban wildlife through a poster presentation ("Communities, Cameras and Conservation") in the local shopping mall. Being environmentally literate requires making decisions using ecological knowledge, while demonstrating an awareness of the consequences of one's decisions and other human actions on the environment (Jordan et al. 2009, Balgopal and Wallace 2009). Environmental education curricula are often designed to teach learners how natural environments function and the way human beings can manage their interactions and dependence on ecosystems in a sustainable manner (Hungerford, Peyton, and Wilke 1980; Tilbury 1995). However, these curricula do not always include strategies for teachers to help their students also become civically engaged. As teachers and students use the local contexts to excite and engage their students, they can ask and answer questions about their local community, seeding the possibility of being involved in local environmental actions (Schusler and Krasney 2008).

Implications

Because civic engagement is a goal of PBE, it behooves curriculum developers and teacher educators to support teachers as they explore how to involve their students in making decisions about their actions. PBE lessons are often interdisciplinary since they integrate socio-economic issues, explore engineering solutions to issues, and require that students communicate their solutions to community members (Howley, Howley, Camper, and Perko 2011). Hence, PBE lessons, because they center on small group work and problem-solving, can help students develop their science argumentation and communication skills (e.g. McNeill, Pimentel, and Strauss 2013). Yet, teacher educators must acknowledge that beliefs and practices about PBE may not always be aligned (Woodbury and Gess-Newsome 2002). Teachers play an important role in addressing local and global environmental issues by supporting the development of environmental literacy of their students. Teachers' concerns about new curricula include the alignment with academic standards and how the curriculum can be modified/implemented in their classrooms. To address this need, we call on teacher educators to encourage teachers to recount past experiences when they have tried adapting and implementing new curricula and ask them to identify how they overcame perceived barriers (Biesta, Priestley, and Robinson 2015). Teacher educators should also consider the extent to which teachers want to implement new curriculum. Teachers are often encouraged to design or modify learning experiences for their students, yet they may not be dissatisfied with the current curriculum. To encourage teachers to adopt PBE curricula, they need to be given opportunities to be constructive participants in their own professional growth that can feed back into their classroom (Davis 2003). For example, teacher educators should engage in dialogue with teachers about what skills and knowledge they believe they need to help them implement PBE lessons as well as, understand the alignment of the curricula with school policies and practices and individual teacher agency (Figure 1). Finally, some teachers expressed concerns about overcoming technological issues (using camera trap technology or managing large photographic data sets). PBE teacher educators should acknowledge that teachers are not likely to use a curriculum that requires them to spend time trouble-shooting technological or methodological issues without support. Although, in our study, community partners expressed willingness to support teachers, we posit that a more active approach may be needed. For example, if community partners share the ways in which they have helped other educators, new adopters may be more receptive to collaborating. In addition, community partners may need to reach out actively to teachers, rather than waiting for teachers to contact them, to demonstrate their willingness to support teachers. Because most academic standards in the U.S. are focused on classroom experiences, teachers may be interested but overwhelmed with how to teach environmental lessons in community-based ways. As our

study demonstrates, engaged teachers and students can find creative ways to share their new knowledge with their communities.

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Notes on Contributors

Diane S. Wright is a PhD candidate in Ecology with a Specialization in Human-Environment Interactions at Colorado State University. Her research on environmental literacy investigates the impact o using place-based education curriculum in K-12 classrooms. Diane has over 25 years of experience in schools as a middle and high school classroom teacher and district level science curriculum facilitator.

Kevin R. Crooks is a Professor in the Fish, Wildlife, and Conservation Biology Department within the Warner College of Natural Resources at Colorado State University. He works with the undergraduate Wildlife Club that is active in engaging K-12 students during school outreach programs.

Don O. Hunter is Science Director for the Rocky Mountain Cat Conservancy, a non-profit organization dedicated to wild cat conservation worldwide. He guides research and community outreach programs with partner organizations. His current research tests the use of infrared-equipped drones to census the wild ungulate prey of snow leopard and mountain lion.

Caroline E. Krumm is Director of the Rocky Mountain Cat Conservancy, a non-profit wildlife conservation organization focused on research and education to promote stewardship. Her research on large mammals in Colorado has added to the understanding of predator-prey and wildlife disease dynamics. Caroline has worked for and with local, state and federal agencies to further wildlife conservation research and education.

Meena M. Balgopal is a Professor of Science Education in the Department of Biology and the Graduate Degree Program in Ecology at Colorado State University. She studies how problem-based group work and writing-to-learn interventions affect how undergraduate students, including pre-service teachers, make meaning of natural and physical sciences. She is a former middle and high school teacher.

ORCID

Meena M. Balgopal http://orcid.org/0000-0002-3846-9256

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