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Connecting to Our Community: Utilizing Photovoice as a Pedagogical Tool to Connect College Students to Science

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Abstract: In this study, we investigated the ways in which university students connected with science through the use of photovoice (Wang & Burris, 1994) as a pedagogical tool. Results indicated that students came to appreciate their connections to the science that operates in their lives as they reflected on and became empowered with regard to the science content behind environmental issues of interest to them on campus. Photovoice allowed students to authentically inquire about local science, as well as the potential to generate change in their own community. This understanding is significant to science educators because first, it empowers learners to connect with science and provides a way to deepen that connection with science; and second, it provides a pedagogical tool for science educators to use with their students to engage them in the science in their community. Finally, it has the potential to improve science teaching by creating students that are more connected to science and th[3]e world around them.

Keywords: *College Teaching, Critical Theory, Empowerment; Photovoice*

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Introduction

Research calling for an educational approach that views science learning as a community practice and the learners as active participants in decision-making processes (Kolsto et al., 2006; Tal & Kedmi, 2006; Hodson, 2003) focuses on developing learners that are producers and creators of scientific knowledge that contribute to community action in collaboration with peers, educators, and community members. Thus, researchers argue that science education should allow students to participate in legitimate ways in community life. In the book *Science Education As/for Sociopolitical Action* (Roth & Desautels, 2002), school science is described as engagement of the students in the solution of meaningful social problems and involvement in debates on political, ideological, and ethical dimensions of the scientific knowledge. Thus, it is argued that science education should encourage students to participate in authentic learning experiences focused on their community. Furthermore, researchers continue to seek ways to bridge school- and community-based "forms of knowledge in support of science learning that is both meaningful and intellectually challenging" (Bouillion & Gomez, 2001, p.890).

In this case study, we sought to create such authentic experiences for students learning science in which the democratic ideals promulgated by a Freirean perspective (1970) to science education could be realized. Specifically, we investigated the potential of empowering science learners to connect with science through the use of a promising participatory action research tool called *photovoice* (Wang & Burris, 1994). This tool has received attention in public health education and community development- and more recently in science education for engaging participants in democratizing the research and learning process. With the use of photography as an innovative pedagogical tool, students take photographs and use the pictures to describe their understanding of science and discuss these photos with informed community members with the aim of empowering students to make changes in their community through their study of science (Cook & Buck, 2010). Developed by Caroline Wang and Mary Ann Burris (1994), photovoice is a method in which researchers provide cameras for participants, whose voices are often ignored in policy-making, so that they may document issues important to them through the use of photography. What sets photovoice apart from other photo-methodologies is that after taking photos and writing narratives about the photos, participants dialogue with informed community members and policy makers about the issues documented in their photographs.

Applied as a pedagogical tool in science education, photovoice puts cameras into the hands of students in order to document and address scientific issues from their position and point-of-view. This technique offers students new and reflective ways to perceive their own world and the science around them, as well as the potential to generate change in their own community. The teachers' role in photovoice is to facilitate conversation and reflection on pictures taken by the students, and then attempt to codify the emergent themes that are generated by collective discussion. Importantly, the teacher must also scaffold an understanding of science content and processes throughout the photovoice process, as well as structure an event to engage students with community members informed about the specific science topic under study. Ultimately, then, students are able to participate in a process that may lead to unforeseen change in their community. In effect, we sought to examine the research question: How and to what extent does the pedagogical tool of photovoice affect learners' connections to science?

Theoretical Framework

Scientifically literate citizens should have the ability to assess the value of and critically evaluate knowledge in a particular context and to participate in the social negotiations that produce knowledge (Bouillion & Gomez, 2001; Roth & Désautels, 2004). Furthermore, scientific literacy can provide individuals with greater control over their lives by enabling them to make better-informed personal decisions; to participate in science-laden policy debates at local (e.g., drinking

water quality), national (e.g., regulation of genetically modified organisms), and international (e.g., global warming) scales (Hodson, 2003). Thus, the call for science education as a pathway to active student participation in science is leading the way for valuing more voices and backgrounds in the field of science, as well as providing opportunities for students to become involved in decision-making about scientifically-related issues. Grounded in a socio-cultural view of learning and a critical approach to educational and societal structures, this shift requires re-conceptualizing science knowledge, science practitioners, and science education, as well as moving from a focus on individual possession of knowledge toward public, distributed activities embedded in particular places and in matters of local concern. Thus, learning science becomes an avenue for social action that emerges in terms of a particular controversy and represents both personal and collective interests.

Current reform efforts in science education research recommend science classrooms should encourage a place for reflection on the social and cultural implications of scientific phenomena supported by research and innovations and that students should be a part of this socio-scientific conversation (Hodson, 2003; Bencze, Alsop, & Bowen, 2009). This study, which aims to investigate the potential of photovoice to bring about reflective deliberation, draws from the work of Jurgen Habermas' *theory of communicative action* (1984) and his notions of the aim for *ideal speech situations* (Habermas, 1984) in education. Jurgen Habermas' "Communicative Action Theory" claims that truth can never be determined by just one actor alone. The best way to reach a valid truth claim is through social integration in a democratic way. This implies that implicit and inherent in any attempt to reach mutual understanding is a presupposition that all voices involved in the dialogue can be reciprocally and equally voiced and attended to on their own grounds. This ideal serves as a standard for recognizing when our attempts to reach mutual understanding fall short in practice. The ideal speech situation necessarily involves intention and the presupposition that we reach mutual understanding through communicative processes. This is especially crucial in laying the foundation for a study that so heavily focuses on communicative acts between non-scientists and the scientific community.

In this study, we draw upon critical theory to create an experience of learning science that empowers students and enables them to connect to a community typically external to non-scientists. Thus, we endeavored to improve the lives of our participants by supporting their notions of agency in being part of the science that operates in their community. As a critical theorist, Habermas' idea of communicative action (1984) underscores the value of dialogue in scientific understanding and advancement. He suggests that truth itself is assumed to exist and possesses the capacity to be understood. So in effect, meaning is always uncertain, fallible, and based upon multiple perspectives; but at best, it is something that can be claimed or agreed upon. The tool of photovoice aligns with Habermas' notions about the importance of multiple voices and perspectives in scientific knowledge. One may presume that not all topics in science lend themselves to a rich discussion of multiple and divergent perspectives. In our study, students investigated environmental issues on campus as these issues offer no easy nor readily agreed upon solutions. The issues instead involved negotiation by many affected parties (political, economic, social, etc…).

Utilizing critical theory and Habermas' idea of communicative action to investigate the tool of photovoice for science education allowed us to diverge from traditional studies of student-scientist partnerships as research apprenticeships (Sadler, 2010) as a means to promote scientific literacy, i.e., employing scientific knowledge and skills to critically engage with contemporary issues and arguments (Levinson 2010). Whereas in these types of studies, the student is meant to acquire the skill set of scientists and maintain an institutional hierarchy that largely neglects democratic participation. We see this in traditional citizen science programs as well-the essence of which has historically been for students to collect data that contributes to

scientists' projects. As Angela Calabrese Barton noted, opportunities for democratic participation in these types of experience are limited:

Citizen science, as a tool, historically has not been about democratizing science-about offering multiple perspectives or transforming a knowledge base or a set of tools or resources- but rather has been about getting more work done (2012, p.2). Instead, we aim here to frame our study through a critical lens aligned with Calabrese Barton's idea of *citizens' science* in which students' employ deep and critical analyses of their connections to community and their sense of place to leverage their contribution to conversations about science that directly or indirectly affects their lives.

Though research on 'dialogue events' is still in its infancy, some potential theoretical grounds on which they may stand are being proposed. Fischer (2000) provided a theoretical and pragmatic exploration of the relationship between citizens and experts, in questions of environmental risk management. Balancing expert perspectives with lay perspectives in policy discussions, which Fischer terms 'practical deliberation', requires that lay-citizens be able to participate substantively in shaping discussions of local environmental concerns. Practical deliberation "seeks to bring a wider range of evidence and arguments to bear on the particular problem or position under investigation" (p. 78). According to this model, understandings of local environmental concerns can be normative and value-laden, but also incorporate knowledge funds ranging from direct observation of the effects of hazard exposure to interpretation of scientific claims in light of personal interaction with a contaminant.

Scientifically literate citizens should have the ability to assess the value of and critically evaluate knowledge in a particular context and to participate in the social negotiations that produce knowledge (Roth & Désautels, 2004). Furthermore, scientific literacy can provide individuals with greater control over their lives by enabling them to make better-informed personal decisions; to participate in science-laden policy debates at local (e.g., drinking water quality), national (e.g., regulation of genetically modified organisms), and international (e.g., global warming) scales (Hodson, 2003). Thus, the call for science learning to be a pathway to active student participation in science is leading the way for valuing more voices and backgrounds in the field of science, as well as providing opportunities for students to become involved in decision-making about scientifically-related issues.

Synthesis of Relevant Literature

In a digital age where images taken can quickly be obtained and shared, photo-elicitation techniques are emerging as important research tools (Litner, 2005, Serriere, 2010). For example, Litner (2005) describes a method of using photographs from around the world with elementary school children as a platform of social understanding. He maintains that educators hold the responsibility to incorporate a curriculum in which learners are able to explore their own ideas of difference documented in our world. His method seeks to confront intolerance and promote understanding of those around the world, useable by both action researchers and educators. Photovoice in this study compliments Litner's work as an experience through which non-scientists can confront their own connections or lack thereof to science in their own community. In this respect, photovoice is used in social justice education with a primary focus on social reflection and student agency.

Outside of science education, photovoice has been used in public health education and community development to connect participants to the community in an effort to inspire change. Downey et al. (2009) used photovoice to explore rural Appalachia residents' understanding of and barriers to public health in an effort to improve the access to resources in the community. Researchers found that although debate was an important part of the experience with photovoice, opportunities to deliberate empowered participants as active members in the community. Another study by Morgan et al. (2010) explored female Nicaraguan immigrants in rural Costa Rica through photovoice aiming to document, critique, and

ultimately to improve life conditions for these residents. Findings indicated "the process empowered these women by affirming their community strengths and providing them with an avenue, through photographs and stories, for voicing their needs to policymakers and community leaders" (p.1). Photovoice is often used among marginalized people, and it is intended to give insight into how they conceptualize their circumstances and their hopes for the future.

The use of photography in science education has been limited, but more recently has been shown to be useful for gaining insight into students' understanding and perceptions and in schools to give students a voice (Furman & Calabrese Barton, 2006; Wang & Burris, 1994; Cook & Buck, 2010; Quigley, Rodriguez, Cook, & Buck, 2010) and discuss content (Wee & Anthamatten, 2012), but also as a teaching strategy for uncovering student and teacher thinking (Quigley et al., 2010). For example, Wee and Anthamatten offered teachers a photographic strategy for eliciting and applying students' everyday ideas about science concepts to enhance teaching and learning, as well as to challenge the standards-based curriculum that holds teachers accountable for what a child remembers rather than what a child actually knows. They asserted that photography allows students to choose images that represent their thoughts and express their positioning within a subject- points of view, biases, and assumptions (p.115). Thirteen sixth graders in a suburban district were provided with disposable cameras and asked to take pictures of land use within the community. Students were also given a journal in which they were guided through a series of questions prompting them to consider their own thoughts and feelings about land use. Data from the photos and the reflections were used to understand how science content resonated with students' own perceptions. As seen in the above example, then, the use of photography offers participants new and reflective ways to perceive their own world and offers researchers new insights and perspectives.

Additionally, Wee and Anthamatten's (2009) strategy of getting middle school students to reflect on their perceptions of land use helped students to interpret their own work and give them an active voice in contributing to the knowledge base about this local issue. They argued that it is not that students do not understand the scientific concepts, but rather that they "do not always understand things in the way expected by adults" (p.118). They suggest teachers need to acknowledge students' everyday ideas about science and understand that meaning is derived from classroom instruction that is constructed in the context of the students' experiences and reality. This notion was echoed in the work of Reeve and Bell (2009) with children ages 9-11 as they sought to uncover ideas the students had about 'healthy' and 'unhealthy.' They discovered that students possessed a much broader notion of their associations with those words than what was being targeted by the health curriculum. Perhaps more importantly, they noted that for the overall goal of promoting children's health, utilizing photos helped them connect this knowledge of children's conceptions to an understanding of what motivates their actual behaviors and practices, and to what extent beliefs such as those cited here are relevant in health decision-making (Reeve & Bell, 2009).

Most recently, the process of photovoice was adapted as a pedagogical tool for science education to empower them to take action in their community (Cook & Buck, 2010). As photovoice not only asks students to document their perspectives about issues relevant and impactful in their lives, it also supports the dialoguing about these issues with those in a position to potentially mobilize change. The photos and narratives alone allow us insight into the minds of leaners, but the community dialogue inspired by the photovoice process holds the power to engage and empower learners in a meaningful way. Thus, photovoice offers a tool for science educators at a time when a case is being made for politicizing students through issues-based, technology-oriented, and place-based curriculum aimed at social critique, values clarification, and preparation for sociopolitical action. In this study, we extend from the work of Author 1 to explore and elucidate the ways in which photovoice underscores these aims of scientific literacy.

Irwin (1995) argued that local laypersons, or non-scientists, contribute unique expertise and serve "not only in criticizing expert knowledge but also in generating forms of knowledge and understanding" (p. 112). It is here, within the exploration of local science, that students can begin to understand as well as participate in scientific issues of personal relevance. Lehr, McCallie, Davies, Caron, Gammon, and Duensing (2007) explored the staging of adult-focused, face-to-face forums that bring scientific and technical experts, social scientists, and policy-makers into discussion with members of the public about contemporary scientific and socio-scientific issues related to the development and application of science and technology. Drawing from experiences in UK-based and US-based "dialogue events," researchers suggest that it may be productive to research and evaluate these dialogue events as "sites of learning." Therefore, one of the goals of this study is to understand what happens when these "dialogue events" are viewed as "sites of learning."

Moreover, through this study we were interested in ways to enhance students' connections to science through community experiences. Because our culture is heavily visual, we wanted to explore the use of photography as a way to connection the students to science. Fyfe and Law (1988) note that the visual is most fundamental of all senses and "depiction, picturing, and seeing are ubiquitous features of the process by which most human beings come to know the world as it really is for them" (p. 2). In this respect, researchers remark that seeing often comes before words and even meaning-making (Berger, 1972). As educational researchers, we acknowledge the challenges that come with heavy reliance on images as a way to construct knowledge. As such, we are cautious that the images used in this study do not become what Baudrillard (1988) calls a simulacrum—in which it is no longer possible to distinguish between the real and unreal. We do this by not only examining visual images solely but by having the participants take the images and write narratives about the photographs. In this way, we utilize the ideas of Mitchel's (1983) 'visual culture' to describe the ways in which images are linked to language and meaning making. Thus, we are interested in how our participants view the images and not just the image itself. Berger sums this idea when he stated, "we never look just at one thing, we are always looking at the relation between things and ourselves" (1972, p. 9 as cited in Rose, 2012). In this study, we continually examine the relationships between the participant, the image, and the way in which the image was produced.

Methodology

Context & Participants

This study took place in two different contexts—both in university settings in classes focused on science content for nonmajors. Our goal was not to compare the two contexts, but to look at experiences using photovoice in the college science classroom that allowed us to gain a deeper understanding of the pedagogical tool in varied contexts. Previously, the researchers conducted a study in Middletown, which is at the forefront of environmental initiatives, with success and therefore wanted to expand the study to two different contexts to see if the technique still enhanced students' connections to science. In the first context, Middletown University twenty-four undergraduates enrolled (15 females, 9 males; 2 African-American, 2 Hispanic or Latino, 20 White) in a Mid-western university class and voluntarily participated in this semester-long study. Middletown is considered a leader in sustainability and sustainability research and recently received several awards of this nature. Author 1 was the instructor of record for the course. The class, *Introduction to Scientific Inquiry*, was comprised of students who expressed an interest in becoming elementary school teachers but were not yet part of a preservice teaching program. The overarching goal of the course was to engage students in authentic inquiry with regard to science concepts prior to learning inquiry-based pedagogy so as to provide them a basis for reflection. As such, activities throughout the semester centered on inquiry, the nature of science, data analysis and interpretation, and

connecting learners with both the on-and off-campus scientific community with regard to local campus environmental science issues. The opportunity for relevant science learning was realized through the use of inquiry projects in which the students investigated on-campus environmental issues (i.e. transportation, water quality, energy usage, availability of healthy food options, greening computer usage, the adoption of e-books, etc…). The photovoice activity was implemented before the students began their campus investigations as a means of generating ideas about the ways in which they could study science locally. The goal of using photovoice in this courses was to help the students uncover what they were interested in studying for their inquiry project and begin to reflect on the science that was embedded in the community around them.

In the second context, Southville University, thirteen preservice middle school science teachers enrolled in a Master of Arts in Teaching (MAT) Program at a large Southeastern public university voluntarily participated in this semester-long study. The students were in their final semester of course work before obtaining licensure to teach science in middle school (ages 12-14 year). As compared to Middletown, Southville recently adopted a recycling program on campus and was just beginning to grapple with issues of sustainability as a part of campus initiatives. Dr. Quigley was the instructor of record for the course. The class, *Environmental Sciences for Middle School*, had the overarching goal to engage students in inquiry with regard to environmental science topics that would be specifically taught in the middle schools in the state where the study took place. The activities were similar to Middletown, centered on inquiry, the nature of science, data collection and analysis- all situated in the local surrounding area. Each student conducted a semester-long inquiry project based on their interests and a problem-area of the local areas (i.e. water quality in a nearby river; stormwater retention; removing funding sources from a local state park). Although the students in Southville were in the preservice teaching program and thus had the focus of teaching students, this inquiry project was meant to provide them with an inquiry experience themselves as a basis for reflection for their future teaching.

Photovoice Process

After basic training on using the cameras, such as manual operation skills and photographic effects like lighting, distance, and picture composition, students were asked to take photographs on campus that showcased an element of their chosen environmental issue and write semi-structured narratives about what they perceived to be important areas of investigation with regard to that issue on campus (see curricular instructions in Appendix A). In choosing their photograph, students were asked which one best depicted the issues they explored. Because they would be asked to showcase the picture and narrative to others and to describe it in depth, they were asked to choose pictures that they were comfortable sharing and talking about. For developing their narrative, they were asked to write about what was happening in the picture, why they took the picture, and/or what it meant to them (ie. Instructional prompts included: Explain what is interesting or important about this issue; What is the issue?; Why is this an issue?; Why is this issue interesting or important?; Who is affected by this issue?; Where is this issue occurring?; When did this issue become evident?; What does the future look like for this issue?)

As a group, each class discussed the overarching themes that constituted a thread throughout their narratives. As a class, we discussed our pictures and narratives together before presenting to the community. Through this discussion, each group found certain common issues or themes emerging. Identification of common themes led us to come up with some main ideas or messages that we collectively wanted to communicate to the community. We used the SHOWED discussion (See Appendix A for detailed information) to generate captions, tell the story of the pictures, and identify the issues and themes that emerged. From the use of these photos and collective discussion, students attended a local community event called Green Drinks to dialogue with

informed community members about their perspectives on the issues. Green Drinks is a monthly public meeting to showcase sustainability-related events and opportunities in the community, as well as a chance for those interested in environmental issues to mingle and network. Typical attendees include on and off campus scientists, business owners, and environmentally conscious citizens. Each event has a host speaker who discusses important sustainability initiatives in the community. The students held their photovoice pictures, which had been enlarged and color printed for the gallery walk event, as an aid with which to discuss their inquiry topics with attendees.

Data Collection & Analysis Techniques

Epistemology in critical qualitative research is essentially communicative in nature, and both its ontological orientation and its accompanying research methodology privilege communicative structures as a way to locate valid truth claims in everyday experiences (Habermas, 1984). As such, data sources were reflective of this ongoing communication. Our data sources included researcher journals, photographs taken by the PSTs, narratives written by the PSTs about their photos, and audio-taped classroom and community observations. Data collection occurred during a semester-long period during which classes were held twice a week for 2 hours each. The photographs were taken and selected by students to present to the community. Pictures captured local campus environmental issues (such as erosion, food waste, transportation problems, etc…) and did not include people unless given written permission.

In the analysis of our data, we used the steps of critical qualitative research. Critical qualitative research consists of several stages (Carspecken, 1996): 1. Compiling the primary record (using techniques such as observation and interviews from a third-person perspective); 2. Preliminary reconstructive analysis (determining interaction patterns, meanings, interactive sequences, power relations, and roles); 3. Dialogical data generation (including the participants in the research). It is within stage three, which democratizes the research process by allowing participants to have a clear voice in the research and challenge the assumptions of the researcher with "their own vocabulary, their own metaphors, and their own ideas" (Carspecken, 1996, p.155). This dialogic data were coded using low-inference codes to classify ideas referenced by participants. Based upon low-inference codes, which aimed to be objective and easily accessible by others, we performed reconstructive coding analyses in which high-level and medium-level codes represented data in symbolic terms, sometimes collapsing some of the low-inference codes. Qualitative data gathered through this research and reported here were analyzed using the grounded theory or constant comparative methodology until researcher consensus was attained. The first phase of the analysis involved coding as many categories as possible from forum transcripts and photovoice narratives. Using this coding, we layered first level codes into families or super codes, and by describing relations among supercodes and between super codes as themes, results in codes, families, super codes, themes. These resulted in the formulation of overarching themes to describe the data.

Validity

The high level of researchers' involvement (here by both teaching and researching the photovoice process) in qualitative inquiry generates concerns about the validity of interpretations. Carspecken (1996) argues that objectivity is defined in terms of credibility and trustworthiness. The credibility of a study depends on researchers' ability to manage subjectivity and limit the extent to which their assumptions and biases shape the findings. Here, we supported the validity of our descriptions of student data by using multiple data sources and a low-inference vocabulary. Both field notes and the thick record of each observation were transcribed using low-inference vocabulary to try to eliminate potential biases regarding what occurred in the setting. Because some biases may have arose despite these attempts, we also used peer de-briefers to check our thick records for potential biases and used member checks with the participants to

ensure that what is in the thick record is what happened as they remember events as well. Because individual experience was the unit of analysis, we were interested in selecting cases that provide a lot of detailed information about the topic of interest, rather than a representative group that will aim to provide insight to multiple populations. Judgments about transferability are based on information regarding the investigator, the setting, the methodology, the participants, and the nature of the relationships between the participant and the researcher.

Findings

Through the analysis, three overarching themes emerged. These themes were: 1) photovoice connected students to the science in their place, 2) photovoice provided the connection to authentic scientific inquiry, and 3) photovoice empowered students to dialogue with informed community members. Below we provide examples and explicate each of these findings with the students' own photovoice narratives as exemplars of these findings.

Photovoice Connects Students to the Science in their Place

The importance and relevancy of place emerged as an essential element for the creation of a space that allowed for a deepened connection between students and the science around them. We assumed that situating their experience in campus issues (specifically, environmental issues that may have a direct impact in their lives) would confer relevancy to the students. We worked before the start of the course to develop a relationship with the campus Office of Sustainability at Middletown University and the Service Learning Alliance at Southville University so that our students could engage with issues we thought would be relevant to them such as energy savings, recycling programs, and campus water quality. There were many projects underway on campus, such as a campus wide Energy Challenge in the dormitories, which we felt would be a match for the objectives of the course content (i.e. scientific inquiry) and to which we aspired in the creation of this experience.

The connecting of students to environmental issues on campus immediately set the tone of the class project as one that focused on solution generation. Students wanted to make their campus a better place and in wanting to do so became easily involved in proposing solutions about what could be done to remedy a problem or create awareness about a campus environmental issue. We had assumed that contextualizing their inquiries in the local campus community would quickly engage them in caring about their chosen issue, and this was highlighted in the enthusiasm student showed in their projects throughout the semester. Below is an example of one students' narrative and photograph about the campus transportation issues she was researching:

As evidenced by her narrative, this student offered her perspective that students should consider biking as an alternative to driving a car based upon environmental considerations and care for our planet. She claims that biking is something in "*which we can all participate and be happy…saving money, preserving land, and preventing a horrific mess*." Her passion for inspiring change on campus was evident in her narrative. As such, photovoice offered participants reflective ways to perceive their own world and showcased to us the students' insights and perspectives on what they believed were important issues for others to consider.

Photovoice allowed the students to deepen their understanding of the science that was taking place around them and also allowed them to investigate scientific topics of interest to them. Bryce pursed his topic of interest (electronic waste) based on what was personally relevant (his father was a trash collector and he grew up accompanying him on his runs). Bryce showcased his photo of computers that had been discarded in the dumpster behind his fraternity and wrote about how his experience with his father offered ideas of alternatives to dumping electronics that could benefit the Earth and also people in need of low-cost computers. He was eager to talk with the community about ways in which the University could help in this mission and began perusing the scientific literature on e-waste as he

questioned the impact the electronic waste had on the environment.

This natural desire to propose solutions to the campus community inspired them to look deeper into the science behind their issue and investigate what others might be doing to address the problem. Ultimately as science educators, we are charged with not only engaging students in science that is relevant to their lives, but also increasing their content knowledge of science concepts. During our study, we discovered that through the photovoice narratives, the students made specific connections to the science content embedded in their issue of interest. Below, a student from Southville describes in detail the properties of pervious pavement. She mentions "*recharging our aquifers*" and "*light coloring of the pavement decreases the heat island effect*" in her narrative as properties of pervious payments.

Similarly, Bryce described the detrimental effects of electronic waste on the environment (referencing a photo he took of a printer that was disposed of in the dumpster behind his fraternity) when he stated, "*these hazardous wastes are seeping into our soils and watertable. This is bad because many people's homes are supplied by the water table and are consuming these toxic chemicals everyday*." Consistently, student began thinking deeper about the scientific topics embedded in their issues, as they wanted to understand the environmental impacts in their local community. While the connection to the content to the content was inspired by the photovoice activity, we as teachers had to purposefully privilege those questions to then guide students to resources that would support their inquiries. Similarly to the examples above, below is an example from a student at Southville describing the

Figure 1. *A student from Middletown describes personal reasons for caring about bicycling on campus*

connection to her local place and the science content she learned about specific animals and plants in her area when she created a field guide of animals and plants for a local state park.

Photovoice Leads Students to Authentic Inquiry

What surprised us, however, about the importance of utilizing the science opportunities in the students' place was not the engagement it fostered, but the natural unfolding of the inquiry it inspired. In an effort to propose solutions about their environmental issue, the students realized they needed to understand the background of their topic and what other universities or communities were doing. Employing place essential not only in enhancing student desire to work on issues to make their campus a better place, but it also allowed for recognition of the opportunity to conduct an authentic inquiry that could lead to clarification about solutions to the issue.

It did not take long for all of the students to use their photos as a platform to start to brainstorm inquiry questions related to science in the community. The photo and narrative below showcases a student inquiring about an old can in a local creek, with the resulting inquiry project focusing on the environmental concerns of water quality and waste management around the watershed. Students used their photos to not only illustrate their community concerns, but to

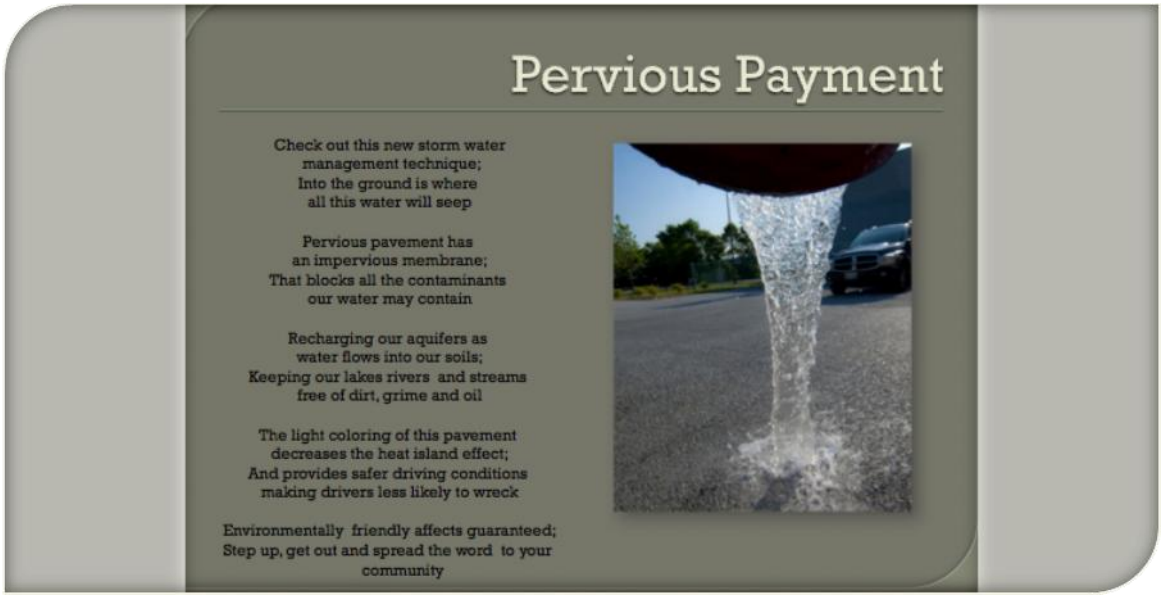

Figure 2. *A student from Southville University demonstrates her content knowledge by describing the properties of pervious pavements*

led easily to this authentic inquiry, rather than us as the instructors having to heavily lead students towards a rationale behind their research. Consistently, students posed questions within their photovoice narratives that could ultimately lead to an inquiry project in the class. We had asked that students pose investigable questions as part of their photovoice assignment, but we did not expect that students would embed them into the narrative- indicating that the view they captured in their photos led them to think critically about what they were observing. We learned that place was also begin asking questions that ultimately inspired their scientific inquiry projects:

In the above example of photovoice leading to authentic inquiry, the student draws upon his experience in which he was cleaning up a stream with students to inquire about, "…what was in the can?" Through his narrative, he continually made predictions about what was in the can. Clearly in his narrative, he was using other forms of inquiry besides scientific inquiry and even infused poetry to express his ideas about the can he found in the river. Later, during his discussions with community members at

Green Drinks, he was able to talk to them about the realities of polluting and dumping in his community. The community members and the student discussed several possible solutions for dumping in the river. In one such solution, a politician asked to use the student's narrative during his next policy meeting on the cleaning up of the river.

In the photo above, s student from Southville asked questions about water usage and how the use of wastewater recycling could be considered a "*new take on recycling*." She conducted some background research to present the percentage of water saved by this type of recycling as a means to identify an extension to the definition of traditional recycling by presenting a unique way in which his community is approaching water reuse. Thus, students naturally developed questions surrounding their photos as they began identifying aspects about which would be important to the community at large (i.e. how does this issue affect others? and how is the community or other communities dealing or not dealing with it?). Here, photovoice was essential for the natural unfolding of the inquiries ultimately conducted by the students. Our choice to place photovoice at the start of the semester prior to students embarking upon their inquiry projects (in which they collected and analyzed data from the community) inspired the fortunate outcome of the students naturally probing for more information that easily led them into the development of their inquiry question.

A diminutive wisp of a creature takes a jerky step onto a waiting hand. Its cool feet feel like droplets of water on her hand, so slight is the creature. Moments before, the girl was hiking rapidly along the trail, keeping pace with her friend. Meanwhile, the red-bodied being meandered on its own path, an injection of color against the neutral leaf litter.

She knew it to be a red salamander, not uncommon in the area. Nevertheless, her heart lifted as she stooped for a closer look. Intercepting its path with her hand, she waited as the salamander crept onto her palm, choosing that moment to snap a photo.

Beyond the scope of the photo, life fills every niche of Paris Mountain. Hikers trek until their muscles ache, bikers slap their wheels against the soft earth, campers listen to the sounds of darkness. All the while rodents flit and burrow, snakes undulate beneath fallen trees, foxes doze in dens. It's a place of parallel worlds, superimposed so nearly yet ultimately disconnected.

As the girl bends to the salamander, a young boy crouches along a stream bed, digging in the leaf litter and finding a dark-colored carapace. Nearby a man and his daughter notice a coiled snake, camouflaged so well as to be almost undetectable. Half a mile away, two teenagers stare, slack-jawed at an overlarge cat with a docked tail.

Hours later, the man and daughter pass through the visitor's center. She reaches for a binder: Field Guide to Paris Mountain, it reads. Flipping through the pages, she finds her snake, eagerly reading its biography. Encounters between the worlds at Paris Mountain are frequent, fleeting opportunities for growth. Knowledge breeds respect, and from respect springs appreciation of our place.

Figure 3. The student connects to her place by describing the field guide she create for a local state park

Photovoice Empowers Students to Dialogue with Community Members

As referenced earlier, students naturally wanted to improve life on campus for themselves and others and as such, photovoice quickly helped them to position themselves as knowledgeable citizens who could make valuable recommendations about their issue based upon their unique position as students on campus. Because part of the photovoice process is to use the photos and narratives to inspire a dialogue with informed community members, we wanted to ensure students felt comfortable talking about their photos and sharing their perspectives with those who may be in positions to affect change in policy. Our concerns about discomfort were quickly put to rest as students were so eager to express their ideas members of the community. On several occasions, students noted their excitement to have the opportunity to connect to "*real*" policy-makers at Green Drinks and participate in "*actual"* dialogue that may lead to authentic change. Rather than merely sharing out in class, students wanted to opportunity to share their photos of their personal experience and lend what could be valuable insider perspectives of students. As such, photovoice offered students some visual "data" they could bring to the conversations at Green Drinks. One student reported that the experience talking to informed community members abut his photo and narrative allowed him to then deepen his understanding of the issue: "*Asking questions to the others who were presenting and getting asked questions made me want to look deeper into my inquiry and think about where I am going with it. Also, we knew so much about*

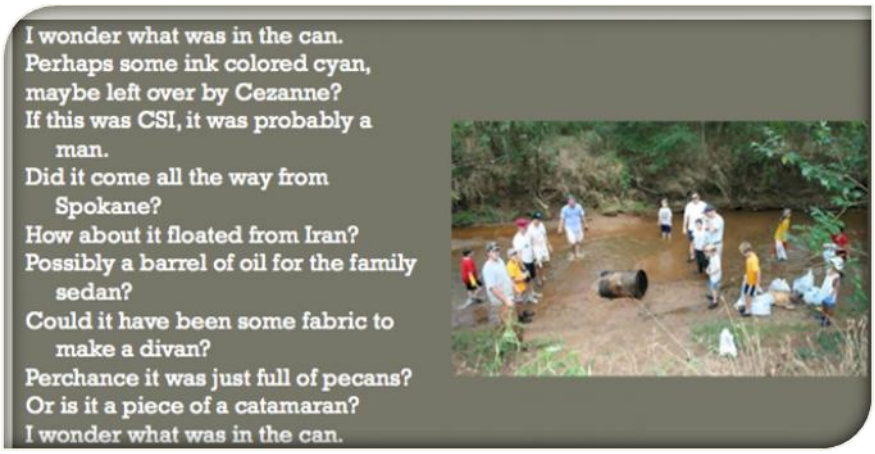

Figure 4. *A student from Southville demonstrates authentic inquiry by proposing a future question in the narrative*

Figure 5: *A student from Southville asks questions to begin probing alternative definitions to recycling available in his area*

our topics- really important topics that not that many people know much about." This reference to the unique part of photovoice, which is to use the photos and a springboard for a discussion with community members who are knowledgeable about the issues, demonstrates the ways in which the students felt this experience was unique to this pedagogical tool. Additionally, besides feeling that they possessed a unique knowledge, the student appreciated the chance to showcase what was important to them: *"We could highlight what we thought was most important in our presentation and that may have been different from what our groups members presented."* Moreover, the students described how the photograph played an important role in this connection to community during this event, "*The photograph served as visual backdrop to the concerns I was having about the water quality in my area. I could point to the picture as I was talking. It is hard to argue with a picture of a polluted lake with kids swimming in it."* This instructional strategy was effective in promoting empowerment among the students and privileging student voice within science learning. Thus, students quickly recognized that in order to speak intelligently with campus community members about local environmental issues, they needed to have some unique information to offer and understand the background in their topic. They also understood that their projects had the potential of impacting local campus policy. Thus, the experience of photovoice being situated in their local place and enabling them an opportunity to interact with the community empowered them to deepen their understanding of the scientific issues and aim to make an impact with regard to them. For example, one student stated this succinctly the benefits of the photovoice "*Overall, the project allowed me the opportunity to delve into an area of science I have no previous experience in. By taking the photograph, it made me pause, 'What was really important to me?' That made me think about my daughter. I wanted something to symbolize the fact I want my daughter to have spaces to play and learn outside. That is why I took the picture of the tree. Doing this project, served as a great introduction to plant species in the Upstate. Overall, I look forward to now being able to have a personal resource for identifying some plant species and being able to pass that small bit of knowledge on to my daughter. I hope to take my daughter to visit Paris Mountain in the near future and show her a contribution her mom made to the visitor's center."*

Discussion Related to the Teaching & Learning of Science

Grappling with environmental issues can hone understandings of environmental science and systemic societal influences and constraints, skills in scientific inquiry, and civic engagement- elements that are crucial to participation in a democratic society, community building, and critical analysis (Battistoni, 2002). Furthermore, research has suggested that teaching about socio-scientific issues can offer an authentic connection to students' lives outside the classroom and should aim to enhance active participation of the learners using methods that reduce the unfamiliarity with science felt by some students (Nuangchalerm, 2010). In this study, photovoice illustrated a pedagogical tool that underscores those aims. Photovoice was essential for both the natural unfolding of the inquiry and empowerment of the students. Through the activity of photovoice, students came to appreciate the connections of the science that operated in their lives as they reflected on and became empowered with regard to the science content behind environmental issues of interest to them on campus.

The researchers acknowledge that photovoice is not the only way to connect students to science in their community nor the best participatory pedagogical method by which to connect learners to scientists. In fact, there are many community-based initiatives that have similar results. However, we posit that the use of photography adds a layer of the visual prompt that helped the students to succinctly describe and begin to question the issue they felt was important. As such, the photographs and narratives served as a springboard to the future investigations. Additionally, the use of photographs provided a visual background to the conversations that were held with the

Figure 6. *Students talk with an informed community member about their photos of energy usage in the dorms*

community, which assisted with the dialogue. When the students were talking about their investigation, they were holding their photographs, which helped to provide context to the issue they were describing. Below we describe the benefit to using the approach of photovoice as one means by which to connect learners to science in their community.

First, the issue of relevancy and place was important in engaging students' in inquiries in which they had the desire to become deeply involved. As we were doing semester-long projects, it was important that students felt connected to and interested in their chosen topic. Dana Fusco (2001) posits that science is relevant because it (a) is created from participants' concerns, interests, and experiences inside and outside science, (b) is an ongoing process of researching and then enacting ideas, and (c) is situated within the broader community. As such, students' choice of their project topics (under the broad umbrella of campus environmental issues) and ability to navigate the ways in which they wished to showcase that interest (through their photograph and narrative) connected them to becoming deeply interested in their project outcomes.

Second, photovoice was essential for the natural unfolding of the inquiry. Thus, as noted above, it is important that students are able to make choices about their project, data collection, and research questions, and it is equally important for legitimate participation that they are able to align themselves with what is of interest to the campus community. As they began asking questions about the science content behind their issue, we as teachers needed to support that learning *in situ* as it came up. Our findings also indicated that teachers should also be guided in developing reflexive and adaptive curricula. Due to the inquiry topics being explored through open inquiry in topics chosen based upon student interest, we as instructors had to be flexible in our course operations and stay tightly engaged in a variety of projects and research designs. With regard to place-based learning, Smith (2007) found that place-based education demonstrated potential for disrupting the regularities of schooling, but required teachers who were exceptionally committed and who were willing to take risks and confront great pressures from the status quo. Here, formative assessment and highly responsive instruction were necessary for the projects to run smoothly, and pre-service

education should highlight these elements within these types of community-learning contexts.

Finally, one of the most compelling reasons to adopt pedagogical tools like photovoice which center on community-based learning contexts is to provide students with the knowledge and experiences needed to actively participate in the democratic process (Gruenewald, 2008, 2003). These features of place-based learning include real-world investigations that have no clear answer, are interdisciplinary in nature, are relevant to both the curriculum and students' lives, and are highly visible and accessible. Students recognized that in order to speak intelligently with campus scientists about local environmental issues, they needed to have some unique information to offer and understand the background in their topic. They also understood that their projects had the potential of impacting local campus policy. Thus, the aspect of photovoice that connected students to the local community empowered them to deepen their understanding of the scientific issues and aim to make an impact in regards to them.

As Flessner (2009) pointed out, teachers must have a motivation to value and honor student voice in the curriculum. We had to carefully structure communication so that no voices were silenced. Rather than creating a project around a contrived or "fake" issue, we wanted students to actively participate in and ultimately have the potential to affect a real campus issue. This view is different from traditional learning in that students have the opportunity to actually generate knowledge on their topic and offer a unique perspective to scientists. Echoing Bouillion & Gomez (2001), science education should at least in part connect directly to expertise and lived experience from beyond the classroom. They suggest one way to accommodate this quest is through new social arrangements for schools, straightforwardly building bridges to communities beyond school. They posit that mutually beneficial partnerships represent one social arrangement that has the potential to create these bridging opportunities:

The challenge is for us and others to understand mutually beneficial partnerships in more principled ways and to identify other social arrangements that may be contextual scaffolds for bridging school- and community-based forms of knowledge in support of science learning that is both meaningful and intellectually challenging (Bouillion & Gomez, 2001, p.890).

Thus, the use of photovoice as an instructional strategy was effective in promoting empowerment among the students and leveraging student voice when the projects were personally meaningful and when they felt they had some ownership over the process. By connecting their inquiry to their place through photovoice, students were given the opportunity to identify and build the knowledge and experiences needed to actively participate in the democratic process. Many science educators support the idea that all students should have fair and equal opportunities to become scientifically literate through authentic, community-based science education (Calabrese Barton, 2000; Bouillion & Gomez, 2001; Hodson, 2003; Roth & Lee, 2004). However, this challenge requires teachers to find ways to help all students feel comfortable with and connected to science. Although not appropriate for all content and curricula in a science course, this study provided insights into ways in which some aspects of a science curriculum could be structured to meet these goals.

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Appendix A

Using Photovoice to Raise Questions about Socio-scientific Issues

Purpose

In this activity we will use a technique called photovoice to discern and discuss scientifically-based issues on campus. Photovoice facilitates the recording of and reflecting on problems of a group or community, promotes critical discussion of these problems, generates collective knowledge of the problems through discussion of the photographs, and promotes individual and collective action to change the problems by reaching out to those who influence or make policy (Wang, 2006).

You and your group members will take photographs that represent the problem you have chosen. Remember to take several pictures that represent your chosen problem, as it will be necessary to discuss and compile them as a group.

Individually, select one or two pictures that best represents or depicts the problem. You will be asked to discuss your photo(s) and your narrative to others and to describe it in depth, so you should choose pictures that you are comfortable sharing and talking about.

Embed your chosen photographs here.

In a narrative essay, address the following questions. Your narrative should be one single-spaced page.

- What is the issue you explored in your photographs?
- Why is this issue interesting or important?
- Who is affected by this issue?
- Where is this issue occurring?
- What does the future hold for this issue and what could be done about it?
- At the end of your narrative, write three investigable inquiry questions related to the topic you explored. We will discuss these inquiry questions as a class.

Write your narrative here.

Photovoice Group Presentation

With your table partners, you will put together a brief PowerPoint presentation on your photovoice topic. This should be a collective effort and each member of the group is expected to contribute to the production of the PowerPoint, as well as present a portion of the final presentation. Each group will have about 10 minutes for their presentation.

Although a group effort, the instructor reserves the right to assign grades differentially based on the contribution of individual group members.

1. Begin by discussing your pictures and narratives with one another. Through this discussion, your group may find certain common issues or themes emerge. Identification of common themes may help you to come up with some main ideas or messages that you want to communicate. Use the SHOWED discussion (below) to generate captions, tell the story in the photos, and/or identify the issues and themes related to your topic.

S: What do you see in these photos?

H: What is really happening here? In other words, what may not be explicit in the photos but is important for you to explain to your classmates about your topic?

O: How does this relate to our lives?

W: Why does this problem exist?

E: How can we become empowered about this issue?

D: What can we do about it?

2. Your PowerPoint should be comprised of the following parts:

Title slide – the title should be the topic you investigated through photovoice and the names of your group members

Body slides – include slides with photos taken by the group. Your individual narratives will be read verbally during your presentation.

Conclusion slide – What can we do about it? – This should be your conclusion slide that offers some potential action that you could take to address your topic.

3. At the conclusion of each group's presentation, class members are expected to offer their insights, thoughts, and reactions to their topic. The most important aspect of photovoice is the opportunity it affords for community members to discuss meaningful problems. As such, you are expected to offer your thoughts with the instructor acting only as moderator, not as discussion leader.

4. Once you have presented, one person in your group should submit your PowerPoint on Oncourse under Assignments (Photovoice Group Presentation). Be sure that all members of the group have an electronic copy of the presentation for their records.

For this activity, you will be assessed based on the following criteria:

Quality and relevance of your photos – do your photos relate to and adequately capture the topic you investigated through photovoice? Did the presentation show a variety of photos related to the topic?

SHOWED discussion – was it appropriately integrated into the PowerPoint and elaborated verbally by group members during the presentation?

Potential for action – did the group offer viable and relevant actions that could be taken to address the problem?

Contribution to class discussion – all members of the group offered their insights/thoughts/reactions to other groups' presentations