

Research Article
**Putting on a Green Carnival:
Youth Taking Educated Action on Socioscientific Issues**

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Abstract: Socioscientific issues in connection to energy production, use or influence on climate change continue to be at the forefront of local, national, and global debates. The pressing nature of these issues requires citizens not only to understand relevant disciplinary knowledge but also to have the ability to use that knowledge to take action. This paper investigates the work of youth in an after school science program designed to examine socioscientific issues as they took *educated action in science* by putting on a “green carnival” for their peers and community members in relation to green energy issues. We approached this study as a critical ethnography working with youth as they planned and implemented a community event. In particular, we were interested in examining what taking educated action in and for one’s community looks like and how youth leveraged community-based and scientific expertise to engage in this work. Our findings indicate that the intersection of place-based and science expertise provided an impetus for youth to take educated action in and for their community. They also indicate that merging place-based understandings with core science ideas resulted in youth creating a space to open dialog and alter the relationship between science and their community. We discuss the implications for science educators to consider the role of educated action in both informal and formal science learning spaces in order to foster civic action using scientific expertise. © 2013 Wiley Periodicals, Inc. *J Res Sci Teach*

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Civic action using scientific expertise is at the forefront of global concerns. Despite attention to the role of science literacy for democratic participation in reform initiatives, civic action using scientific expertise continues to play minimal roles in science education for two reasons. First, science education policy has been grounded in the idea that scientific understanding is enough to prompt informed and reasoned action (e.g., AAAS, 1989; NRC, 2012). However, research suggests that scientific understanding bears little impact on the decisions people make on civic engagement (Allum, Sturgis, Tabourazi, & Brunton-Smith, 2008; Sadler, 2004). In the United States, the new framework for science education and the Next Generation Science Standards (NGSS) further cements this divide, with almost exclusive attention on the cognitive dimensions of science learning (NRC, 2012). Second, science subject areas that often have civic engagement as a centerpiece, such as environmental studies, still emphasize the content without fully considering political, economic, or social dimensions of issues and students’ connections to them (Bowers, 2002). Even when instruction includes action-oriented goals and activities such as

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implementing recycling programs, there is often little consideration for how or why youth might engage such problems (Stevenson, 2007).

And yet, as the health of our planet continues to be impacted by human behaviors and interactions with various environments, it has become clear socioscientific issues connected to energy consumption are not simply worries earmarked for future generations. The shifting timeframe of concern places a greater importance on building understandings of energy-related issues and taking action based upon those understandings (Skamp, Boyes, & Stanisstreet, 2013). Thus, we see an individual's capacity to build understandings and take action on socioscientific issues of local, national and global importance as a responsibility of democratic citizenship for both adults and youth alike.

This type of informed civic engagement requires aspects of both knowing and doing, a concept we name as *educated action in science*. We define educated action in science as the capacity to leverage relevant scientific knowledge and practices to inform action(s) taken. In this manuscript, we focus on what educated action in science looks like, what understandings of science and community are leveraged when taking educated action on socioscientific issues in their community, and its implications for science teaching and learning. We assert that educated action in science requires leveraging multiple areas of knowledge, including scientific and place-based knowledge, as well as the desire to act.

The questions that guide our paper include: (1) What understandings of science and place shape middle school youth's educated action in science? (2) How do youth leverage these understandings to take educated action in science? And (3) What forms does their educated action take, and how are these forms responsive to the connections youth make between science and place?

This study provides insight into the ways in which scientific knowledge and place-based understandings are drawn upon and connected by youth as they civically engage with socioscientific issues facing their community. Thus, this study reveals important lessons for science educators about when and how science matters when taking educated action, how educated action in science requires more than science content knowledge, and how youth work to bridge science and place in order to make a difference in their community.

Conceptual Framework

Educated Action in Science

Educated action in science involves the capacity to leverage relevant and multiple areas of knowledge and practices to inform democratically responsible actions. This idea stands in contrast to current environmental campaigns instructing people in particular behaviors, without attention to how or why those behaviors matter and the evidence in support of those explanations.

We see educated action as an important goal in science education if our aim is to support using one's understandings of scientific knowledge and practice to participate in democratic society. However, taking action has not traditionally been a central aspect of school science curriculum, especially in the United States. Examples to the contrary (see Sperling & Benze, 2013; Tal & Abramovitch, 2013) highlight recent curricular initiatives outside the United States that aim to include action or activism in studies of environmental education or socioscientific issues. Despite these examples, school science has traditionally focused on the acquisition of knowledge and the general processes of scientific practice (Lemke, 1992; Newton, Driver, & Osborne, 1999; NRC, 2007; Rudolph, 2002). Lee and Roth (2003) argue "current practices of science education focus on students' conformity to authoritative knowledge and scientific discourse that are relevant to research scientists" (p. 404). This approach to science education isolates scientific knowledge and

practices from individuals lived experiences and the immediacy of community life (Gruenwald & Smith, 2008).

Since we believe educated action in science is an important goal in science education and for developing scientifically literate citizens, in what follows, we first examine how educated action is addressed by current constructions of science literacy. Next, we turn to the role of place in expanding our understandings of how and why youth might take educated action.

Educated Action and Science Literacy

In order to take educated action in science, an individual or group must have expertise regarding scientific knowledge and practices relevant to the socioscientific issue being investigated (Kolsto, 2001). Anderson (2007) defines science literacy as “the science-related knowledge, practices and values we hope students will acquire as they learn science” (p. 5). Many scholars as well as recent reform movements in the U.S. point to developing a scientific literate citizenry as one of the primary purposes of science education (Anderson, Holland, & Palinscar, 1997; Lee & Roth, 2003; NGSS, 2013). However, there are differing opinions and approaches on what a scientifically literate person knows and is able to do. Roberts (2007) categorizes the literature as attending to or promoting two different visions of scientific literacy—one vision promoting the “canon of orthodox natural science, that is, the products and processes of science itself” and the other vision interested in “situations with a scientific component, situations that students are likely to encounter as citizens” (p. 730). The first vision, traditionally aligning with school science, focuses on the knowledge needed to be scientifically literate leaving the application largely to the individual or group, whereas the second vision is focused on contextual applications of this knowledge and processes. Feinstein (2010) expands this second vision by reconceptualizing the scientifically literate citizen as one who is a “competent outsider with respect to science” (p. 180). A “competent outsider” has the ability to identify places where science is “useful” to the question or issue they encounter. Feinstein (2010) argues that “science literacy is not incidentally but fundamentally about identifying relevance: Learning to see how science is or could be significant to the things you care about most” (p. 180).

Building on Feinstein’s argument, we believe paying attention to how science concepts or practices can be useful often indicates a much more expansive view of where science takes place and who can carry out this work. The knowledge and capacities that go along with being scientifically literate are not confined to the traditional places of science (i.e., laboratories, classrooms), nor are they only carried out by those traditionally labeled as scientists or the smart science student (Carlone, Haun-Frank, & Webb, 2011). Instead, an individual must be able to find science useful in the communities where s/he lives, works and cares. In order to enter these communities, epistemic authority is shared, and is considered along side other ways of knowing when encountering and acting upon personally and socially meaningful issues in local, national or global contexts. As Lee & Roth (2003) argue, “science is not a singular normative framework for rationality, but merely one of many resources that people draw on in everyday collective decision making processes” (p. 2). Thus, this conceptualization not only values scientific understandings and practices, but also the ability to appropriate these in ways that are salient to specific communities and work in conjunction with other relevant forms of knowledge and practices.

Educated Action and Place

Our work in informal settings suggests to us that integral to developing science literacy and the desire to act upon science understandings is a connection to place. As we have seen elsewhere, instead of separating content and context, mind and body, as is often the case in education, youth creatively leverage science understandings and practices in ways that are meaningful to their

community when given space to do so (Calabrese Barton & Tan, 2010). We believe place is a key component in educated action in terms of youth's desire to take action, identify relevant socioscientific issues facing their community and as inspiration to learn more about the relevant scientific knowledge and practices in order to inform that action. Thus, we turn to the literature on place to enrich the discussion of science literacy.

We view place as a multidimensional phenomenon (Ardoin, 2006). People experience place through its biophysical dimensions as well as through its historical, sociocultural, economic, and political dimensions. How one makes sense of that experience is related to how s/he is positioned among these differing narratives (Gruenewald & Smith, 2008). One's "sense of place" is dynamic, for it is a reflection of one's on-going relationships in and with the world. How one is positioned through race, class, language, culture, and so on, both historically and in the moment, shape how and why one understands place (Cogan, Grossman, & Liu, 2000). For example, how residents experienced and understood Hurricane Katrina and its impacts across the southern United States, but primarily in New Orleans, Louisiana, is intimately tied to race and class. The hurricane significantly impacted lower-economic, and primarily African American, communities who relied on public transportation at rates four times higher than their white and more economically advantaged counter parts. In addition, their homes were built in ways and in locations more susceptible to hurricane damage (Pastor et al., 2006).

Thus, the multidimensional aspects of place are a powerful influence on the ways in which an individual and/or groups engage with environmental issues (Gruenewald & Smith, 2008; Noddings, 2005; Umphrey, 2007). Recently, work on environmental justice fronts has paid more attention to the everyday enactment of environmental concerns—or the lived experiences of environmental *injustice*—among low-income communities and communities of color (Brodkin, 2009). Environmental justice is located not only in anti-toxic movements, but also in how the *boundaries* of environmental issues are framed across race and class. This work recognizes that how individuals are positioned with respect to place matters to the ways in which they take up environmental issues, what dimensions of place are drawn upon for sense making and the degree to which they feel empowered to take action.

Insiderness

It is not only how an individual is positioned with respect to place that matters for taking educated action, but also how an individual positions themselves *in* their place. A framing dimension within place is the idea of insiderness, which matters for the types of place-based expertise an individual can draw from when encountering a relevant scientific issue. For example, youth have been shown to exhibit "environmental understanding" and "environmental navigation" (Lim & Calabrese Barton, 2010) in relation to their place. This involves having contextualized knowledge, awareness and navigation skills that allow youth to interact with various members of the community and maneuver through (or around) physical and social spaces in their community. For these youth, their knowledge of what is happening in their community, what is important to people and how to navigate these spaces affords them a position of insider. The identity of an insider brings with it a certain level of expertise that can be leveraged when making decisions or considering courses of action. Youth's experiences in their local community lead to an understanding of their place that is layered and continually redefined as they gain experiences within the community.

In this study, the identity of insider also allows youth to employ a critical eye to people, places, and situations in their community due to a contextualized understanding of their place. We conceptualize this as a *critical understanding of place*. This view results in determining aspects of their place that are "good" and "bad," as well as allows youth to recognize

the nuances and multiple layers between these determinations. This critical understanding of their place may lead youth to identify socioscientific issues that can be addressed in their community. It may also lead youth to challenge people and perspectives they believe play important roles in determining what happens or what matters in their place, especially when these people may lack the environmental understanding and navigation necessary that the youth themselves possess.

We argue a multidimensional view of place is central to the ways in which youth examined socioscientific issues and took educated action in this study through serving as an impetus for taking educated action as well as shaping the action taken. As youth encountered new scientific knowledge, it was considered along side narratives they brought with them from personal and collective experiences in their place. Understanding how and why youth leverage different dimensions of place to take educated action is vital as we continue to examine how science education can be “useful” in their lives.

Method

Our study was carried out as a critical ethnography, a *methodology* for conducting research focused on the goals of participatory critique, transformation, empowerment, and social justice. A merger between critical theory and ethnography, critical ethnography is grounded in the idea that researchers can use the tools of ethnography to conduct empirical research in an unjust world in ways that examine and transform inequalities from multiple perspectives (Trueba, 1999). Thus, critical ethnography provided an approach in which to “politicize” the interaction between actors and the social structures through which they act, grounded in the belief that these relationships are never neutral. Anderson (1989) argues the critical ethnographer is concerned with the “relationship between social structural constraints on human actors and the relative autonomy of human agency” (p. 249) This approach was important as we attempted to capture the educated actions taken by youth who are positioned in particular ways due to being young, female students of color from predominately low socio-economic status working through complex socioscientific issues.

We employed this methodology due to the desire to conduct research “with” participants, rather than “on” or “for” them (Calabrese Barton, 2001; Thomas, 1993). Our work with GET City youth blurred the lines of the traditional researcher/researched relationship. We assumed multiple roles throughout the project acting as teachers, collaborators, and researchers. This afforded us access and positioned us as members of the group who had various degrees of influence on the direction of inquiry as the investigation progressed. Youth also assumed multiple roles throughout this project as they created, planned, and implemented the carnival. The multiple and overlapping roles taken on by the youth blurred the lines of being educators, community members, and researchers who desired to communicate their findings of energy investigations with the public in meaningful ways.

Our history with these youth, working alongside some for more than 3 years, opened spaces for youth to take on leadership roles during the green carnival as well as speak candidly about issues they believed were facing their community. In order to uphold our commitment to conducting research with youth, we took steps to foreground and represent their voices in our data collection and analysis. These steps include our role in (1) supporting the youth in their planning and creating the green carnival (providing intellectual, material, and social support in their efforts to carryout their vision of a green carnival), (2) providing opportunities for on-going talk, idea development, and feedback on the planning process through weekly large and small group conversations, and (3) following up on the youth’s desire to “get the word out” so that other youth would see that they could do this kind of work, too. This last point is central to why we are writing

this paper. While we encouraged some of the youth to write this paper with us, they declined given other school and family commitments.

Additionally, a central tenant of critical ethnography is that the outcomes of research serve the needs and desires of the different participants (Trueba, 1999). What that means is that research outcomes typically reflect more than the traditional academic article. For GET City youth (and initially the adult researchers), the outcome of this research was the carnival itself. Through the conversation groups, where this research began, the youth identified a need for community members to become educated on green energy issues that would save them money and help their community environment. We also realized, retrospectively, that the green carnival, as its own event, was a space of educated action. It became the focus of our analysis and writing. The paper also became an extension of youth's desire to "get the word out" about their work with science in their community. Although the youth did not "write" this paper with us in the traditional sense, we argue that this research was carried out with youth as they directed the study through their talk about what mattered to them in science and community and the action taken as a result of this talk. The research questions and findings emerged from youth talk through the conversation groups and the carnival itself.

Context

The study takes place in Great Lakes City,¹ MI, an urban area that has seen severe economic decline over the past few decades. Once a hub of the automotive industry, the city's population decline has mirrored the dwindling presence of the auto industry with a 13% loss from 1970 to 2010 (U.S. Census, 2010). The loss of industry hit the community hard, resulting in a July, 2011 unemployment rate of 9.2% (Bureau of Labor Statistics, 2011). One can easily recognize situations of urban plight in Great Lakes City such as closed automotive factories, boarded up houses, and other evidence of economic decline situated among fading visions of what the city used to be. While the economy of Great Lakes City has seen decline, there are still many vibrant aspects including recent investment in revitalizing a waterfront area as well as strong community organizations. One example of this community vibrancy can be found at the site of this study, the local Boys and Girls Club.

The Boys and Girls Club of Great Lakes City has served the community since 1964 and welcomes over 2,400 youth annually between the ages of 7 and 17 from predominately low income and minority backgrounds. The club provides a safe place for youth to engage in many activities allowing opportunities to play, learn, and have fun. One of the programs offered to members of the club is an informal science learning program called GET City.

GET City

GET City is built on the premise that meaningful learning happens when youth engage in authentic investigations of local energy and environmental problems with scaffolded opportunities to communicate the findings of those investigations to others. It does so by providing a year-round after-school program that emphasizes youth development into science and engineering *experts* and *citizens* by using technology to take on relevant green energy issues and communicate findings to their community. There are three organizing components of GET City designed to support youth learning and development in science.

Building STEM Expertise. Youth engage in *authentic scientific practices*, which include asking research questions, developing, testing, and revising scientific models, collecting data, analyzing data, and defending findings. GET City investigations emerge from youth's questions

and interests that are generated through talk about current events and discussions of energy concerns in our city and state.

Building STEM Citizenship. Youth develop *multimedia products* that convey scientific messages meant to educate particular audiences on energy issues. These products address the question, “*What’s important for others to know about my investigation?*,” encouraging youth to discern the most salient scientific messages. Multimedia products include (but are not limited to) digital public service announcements, podcasts, and raps.

Educating Others. Youth put their knowledge and products to work through the *GET City Education Network*. Within this network, youth work with project staff, teachers, and community leaders to develop scientifically rigorous educational activities that draw upon their multimedia products to teach about energy and the environment in ways that align with school/community needs. In the past, youth have taught lessons to their peers at school and hosted community events at the Boys and Girls Club.

Curriculum

During the 2010–2011 school year, the year in which this study took place, GET City youth were investigating the “energy crisis” in Great Lakes City in terms of the rising costs of energy situated within competing narratives of a declining economy and the ramifications of climate change. Youth approached the investigations through the idea of efficiency, looking at both technological innovations as well as human behaviors that impact total energy usage. In the previous year, the youth investigated the “change a light, change Michigan” policy initiative as a way to delve into energy conservation and efficiency through technology design, looking closely at energy transformation. Collectively, the youth and adults involved in GET City decided it made sense to build on this knowledge/experience by looking at the broader problem space: How much electricity does our city use? Why does it matter? And, what else can we do about it? The goal of the year-long investigation was to look at electrical production, supply and demand, environmental impact, and to examine the potential role of alternative “green” energies. Early in the fall semester, youth investigated their own personal carbon footprints and that of the Club and their families. In late fall, the youth dug into how electricity is produced in their city (e.g., energy and its forms, energy conversions as coal is used to produce electricity), the impact of electricity production on the environment (e.g., carbon emissions and climate change), and investigating and comparing forms of new energy technologies on the production system and its impact on the environment (e.g., solar, wind, bio). During this time they visited a local coal plant, conducted energy audits of their home, the club, and their local schools, and investigated multiple sources of electricity production with engineering students from a nearby university.

For example, during one data generation activity, youth identified appliances used in homes today as compared with two generations ago through interviews with family members. They gathered data on current appliances and their usage using kilowatt meters. They also examined the club’s electricity bill closely over the course of the year, comparing energy expenditures during different seasons, and hypothesizing what the sources of energy usage were. Using calculations of energy expended, they constructed a bar graph to show changes in appliance use over a period of time, compared this to graphs of carbon emissions over time and developed explanations regarding the environmental impact of increased energy use as well as the influence on their families’ energy bills.

Participants

The target audience for GET City are Great Lakes City area youth from underrepresented backgrounds. This is the same demographic that attends the Boys and Girl's Club and schools on the south and west sides of Great Lakes City. Child poverty in Great Lakes City has increased over 40% since 2000 (MI League for Human Services, 2009). 27% of Great Lakes City children live below the poverty line, with the rate jumping to over 40% for youth from African American backgrounds. We strive to recruit a variety of youth with a range of skills and interests. We believe that recruitment and programmatic enactment must acknowledge the economic difficulties families face. GET City responds to local economic and equity-related realities by providing resources that allow youth opportunities to engage with technology, interact with community leaders and local science partners, and visit sites of science learning and doing around and beyond their community. Additionally, we recognize that many youth possess aptitude and potential that may not yet be realized or observed in standard measures. For example, youth who have not performed well in school in general or in school science, or who are not interested in science, are encouraged to participate in GET City. Within the program, we try to open spaces for youth to leverage the various forms of expertise and interests they bring to studying energy and their environment by incorporating and valuing art, technology, and community concerns.

Data analyzed in this paper are focused on a subset of six GET City youth. These youth were chosen primarily due to leadership roles each assumed in creating, designing, and implementing the green carnival. This included coming up the idea for the carnival, proposing, and leading a discussion of the carnival with other youth in GET City, overseeing which energy technologies and messages would be shared at the carnival, working with adult leaders to secure materials and supplies for the carnival including give aways for each booth, and designing the layout of the carnival space. These six participants also were regular contributors in small group conversations with one of the researchers before and after the carnival. Specific participant data is represented in Table 1.

All six of these participants are African American females between the ages of ten and thirteen. The girls were in 5th, 6th, or 7th grade dispersed in several local schools during the 2010–2011 school year. We did not set out to only include females in the study, however, participation in GET City during 2010–2011 was made up of almost entirely females from 5th, 6th, and 7th grade and thus these six females are representative of the group for that academic year. Specifically, of the 21 Get City members in 2010–2011, only 2 were males. In addition, eight members were in the 5th grade, seven were in the 6th grade, four were in the 7th grade, and only two were in the 8th grade.

Table 1
Participants

Name	Grade	Years in GET City
Jessie	6th	2
Chantelle	6th	2
Angelica	6th	1
Maya	5th	1
Tami	6th	2
Janna	7th	3

Data Generation

The findings of this paper are based on data collected from multiple sources and include:

Conversation Groups. Each week, during the school year, a researcher met with GET City youth to debrief and develop a stronger sense of what they cared about with respect to green energy in their community. These informal conversations were held for 10 weeks each lasting between 60 and 90 min with one of the researchers and 3–6 youth. These meetings were a place where the GET City curriculum and other issues in their community were discussed, debated, and deliberated upon. Topics of conversations groups and number of meetings devoted to that topic included defining who and what a Community Science Expert is (2), describing Great Lakes City to someone who has never been there before (2), drawing, labeling, and discussing a map of the community (1), sharing stories about a specific experience(s) in the community with green energy (2), deliberating upon the green energy concepts we were learning and planning action in various locations in the Great Lakes City including the green carnival (3). All conversations were audio recorded and student artifacts were collected and analyzed when applicable.

Interviews. One on one interviews were conducted after the green carnival with four youth (Chantelle, Jessie, Angelica, and Maya) to discuss and reflect upon the experience. Interviews focused on perceived visitor experiences including visitor interaction with green energy science, identities youth took on in planning and implementing the event, successes, and areas in which they would like to improve future green carnivals and perceived contributions made to the community.

Green Carnival Artifacts. First, materials the youth generated for the Carnival were collected, and include: movies, PowerPoints and posters, photos of experimental set ups, the green carnival passport, and activity sheets. Second, responses from a student co-authored survey given to visitors as they left the carnival were collected and analyzed. These data provide insight into interactions between GET City youth and community members as well as salient messages for green carnival visitors.

Green Carnival Descriptive Data. First, during the carnival, 10 video cameras were set up strategically at each youth exhibit to capture interactions between youth and visitors. Second, one researcher conducted several short impromptu interviews with GET City youth during the event aimed at gathering initial reactions to and feedback about the carnival in the moment. Third, the three adult researchers who were part of the event wrote field notes that were shared and discussed immediately at a follow up research meeting. Notes were taken during this meeting. These data allowed us to provide a rich description of what happened during the green carnival including specific examples of youth's interaction with visitors.

Transcripts of GET City Sessions. Each week, GET City was video and audio recorded and sessions were transcribed. GET City held 20 regular sessions from October 5th, 2010 until April 21st, 2011 (the week prior to the green carnival) that lasted approximately 90 min each. We turned to these videos to situate and to make sense of students developing understandings and decisions.

Student Work. We collected artifacts youth generated as they investigated various green energy issues through the school year, for the green carnival and as they prepared to educate the community (i.e., movies and raps about green energy and climate change, posters on alternative energy, PowerPoints and web pages, and key data representations used in support of these, such as tables, graphs, and maps). We also drew from student work created in previous GET City units that

emerged in youth talk about the green carnival (i.e., public service announcements and video shorts prepared by the youth and brought up in class discussions). Finally, periodically students posted online entries updating the community on the progress of their investigation, which we also examined to think about youth's growing science expertise and methods of communication with community members.

Data Analysis

Data were analyzed using constant comparative analysis by identifying themes among and between participant experiences (Glaser & Strauss, 1967). The first phase of analysis examined themes apparent in interviews, conversations or observations of group meetings and activities. We first identified segments of data within the interview transcripts, field notes, etc., that included youth's stories about what it meant to take educated action in their community. For us, this meant that these were segments where youth talked about using science to take action in their community, broadly speaking. Those segments were then coded with respect to themes such as science knowledge and practices, multiple dimensions of place, and relevance to community as guided by the conceptual framework. This analysis allowed us to elaborate on how youth constructed what it meant to take educated action in and for their community, on their own terms and through their own examples—that is, through stories of who they are, who they want to be, and how they view themselves in specific contexts.

Next, we analyzed each youth's participation to make sense of the actions they took and the ways in which those actions connected to their talk. We examined videos taken at the green carnival, regular GET City meetings, and other GET City events in the community. This analysis allowed us to examine overlapping and outlying themes between youth narratives of taking educated action and the observed nature of action taken in their community.

Finally, we examined talk and educated action taken across participants. We compared themes emerging in stories, interviews, group conversations, student work, and green carnival videos. This analysis allowed insight into the individual and collective meaning making of youth as well as the range of experiences and expertise they drew from in that process. This analysis provided insight into what was shared in terms of the desire to take action and the scientific knowledge leveraged in order to educate community members.

Findings

Our findings detail the ways in which the youth in our study took educated action in science as they designed and implemented the green carnival at the Boys and Girls Club. We divide this section into three main areas of findings, which align with our research questions: (1) Understandings of science and place, (2) how the youth leveraged these findings toward educated action, and (3) the forms their educated action took, including how these forms were responsive to the connections youth made between science and place.

Understandings of Science & Place

The Green Carnival: Energy Messages for the Community. We view the youth's efforts to initiate, design, and enact a green carnival as educated action in science, in a broad sense. However, it is in the specific work the youth took on to plan and enact the carnival that we are able to consider, in more robust ways, the understandings of science and place that shape educated action. Thus, we begin this section by examining the youth's planning and enactment of the green carnival.

On April 28, 2011, 21 GET City youth welcomed over 100 visitors to the first ever “green carnival” at the local Boys and Girls Club.² On this afternoon, the yellow walls, cafeteria-style furniture, and drop ceiling that usually defined the club room were transformed into a carnival-like space. Youth-created exhibits filled with experiments, informational hand-outs, and different energy technologies were set up around the perimeter of the room. Youth-designed energy themed decorations hung from the ceiling, and posters donated from local businesses and organizations were stuck to the walls. There were also games, music, and food for all attendees to enjoy. The attendance by members of the community far exceeded even the most aggressive estimations by either the youth or us. One hundred youth-created passports, given to visitors to mark their travel through the carnival, were gone well before the final guests arrived. The club room was filled to capacity by parents, peers, and other community members interested in learning more about green energy, forcing lines of eager visitors to form outside the entrance. When asked after the carnival what she was most proud of, one of the youth, Jessie, said, “that I accomplished something that I haven’t accomplished before. I have never made anything this big before.”

The Carnival was, in many ways, the culmination of nearly 2 years of research. The exhibits, and the ideas they were intended to teach, drew from the research the youth had done, and the artifacts they had created as part of that research process. Throughout the planning process, youth leveraged their prior experiences from previous GET City investigations to draw upon understandings they developed regarding energy-related science as well as artifacts they created that could be shared at the green carnival.

The green carnival was designed by the youth because they wanted to educate their community about green energy, why it matters, and what community members can do at home to be green. The youth felt that they had become “experts” on these topics, and had ideas they wanted to share. As Jessie noted in an interview at the carnival, “I want to teach other kids about how bad the Earth could be or how bad it is and how you can make a change in the world. Someone might say, ok, it’s just coal or it’s just gas and we can get more, but now they can teach someone a lesson.” The youth felt that “sharing what you were learning in GET City with other people” would be “something good for the community” (Maya, post-carnival interview). This goodness encapsulated the promotion of green practices while supporting an economically distraught community. As Jessie states, the green carnival would also allow them to “raise money ourselves and buy [community members] CFL’s and green things for their electricity. . . Because of how bad our economy is.”

After months of planning, the vision for the carnival shifted from simply wanting to do good to a rationale for what they should teach and why. Through small and whole group youth led conversations, the youth settled on 10 different youth-designed exhibits, which covered 3 main green energy messages they thought had important local applications and practices that people could incorporate into their lives. These messages include: Energy efficiency and technological advances, energy and the environment, and renewable energy technology. Woven across these messages was the idea of human impact on climate change and strategies for mitigating carbon emissions. These messages offer insight into the scientific understandings that youth leveraged toward educated action. As we discuss below, each of these messages was associated with particular practices they hoped community members would take up, and with particular experiments or demonstrations they could enact at the Carnival to teach others about the meaning of these themes.

Energy Efficiency and Technological Advancements. One of the exhibits with which visitors interacted was the “Light Bulb Efficiency” exhibit. Throughout the evening, the three girls who led this exhibit were heard enticing guests to their booth by asking to passerbys, “Can you tell

which light bulb is more efficient? Or, which one might be better for your home?" These comments were meant to entice visitors to their exhibit and at the same time pointed toward energy-related ideas they wanted visitors to think about.

This exhibit was designed to teach visitors about energy efficiency, which required the girls to know something about how light bulbs work, energy usage and how that is measured, and energy transformations (particularly in *inefficient* devices). At the same time, a closer look at this exhibit reveals how the girls connected their scientific understandings to community concerns (costs of bulbs, life of bulbs, energy bills, and safety), and potential actionable steps for their community (replacing bulbs).

The girls designed the exhibit around an investigation they had conducted the previous year regarding a state-wide initiative asking citizens to swap out their incandescent light bulbs for CFL's. Based upon their experience studying energy transformations and efficient technologies in relation to this initiative, the girls devised an exhibit at the green carnival with three primary components: (1) A PowerPoint presentation, (2) three experiments related to energy transformations and light bulbs, and (3) a movie they created about light bulb efficiency. As new groups of people interacted with the exhibit, the girls began by asking attendees "what makes a light bulb good?" With cues on their PowerPoint slide, they got participants talking about "brightness," "cost," and "how long it lasts." However, the girls then challenged their attendees to consider how their light bulbs were powered, and if they knew how much power their bulbs required. Telling participants, "power consumption reflects how quickly energy is used, and is measured in watts," the girls got out two different bulbs—an incandescent and a CFL—and placed them in equivalent small table lamps. After demonstrating how to use a kilowatt meter, they asked participants to measure both bulbs' energy consumption. They followed this task by asking, "What did you notice about the difference between the amount of power an incandescent light bulb uses compared to a CFL?"

The girls then walked their visitors through two more experiments: Measuring and comparing brightness in lumens, and comparing heat output through temperature. The excitement was palpable. From across the room, you could hear the girls literally screaming with glee, "As you can see, the CFL emits 830 lumens of light and the incandescent emits 600 lumens of light. That means that even though the CFL uses less energy, it puts out more light than the incandescent!" One of the girls could be heard asking each of the passerbys if they felt how hot the incandescent bulb was—reminding them that transforming electricity into heat wasted energy. The girls' statements show understanding of energy efficiency and energy transformations.

The girls then summed up what they wanted others to know based on the evidence provided by the experiments, "Both bulbs generate light and heat. The CFL generates more light and less heat. The incandescent is wasting energy because it is creating too much heat. So, the CFL is more efficient because it uses less energy to generate more useful light." They concluded their presentation by warning participants of the mercury hazard of CFLs and suggest that LED lights might be the way of the future, even though at the time (2011) they were extremely expensive, and hard to find in their neighborhood.

As the next group moved in, the girls gave out free CFLs along with a pledge, asking participants to agree to change their bulbs at home. They also directed them to watch a 4-min video documentary they created with their peers describing a recent light bulb audit they did at their school, which explained the process of conducting a light bulb audit, the science behind the importance of efficient light bulb technology, and the human impact, including a statement on how much money they saved their school annually.³

After the light bulb experiments and movie, visitors moved on to an exhibit where two GET City youth showed an additional movie they made about energy efficient behaviors and

technologies more broadly, covering science ideas such as electricity production in Great Lakes City, how we measure energy consumption, and how changing behaviors at home can impact local environmental quality as well as the size of energy bills. Patrons who watched the movie answered energy questions asked by the youth, such as “why is using electricity efficiently important?” to win prizes donated by local organizations. The youth purposefully put this exhibit after the light bulb exhibit to show visitors how their energy knowledge could impact the places in which visitors lived, worked, and cared.

The energy efficient exhibits were most often referenced in the survey given to visitors at the carnival. One adult who attended wrote that s/he will “use different light bulbs based on the temps and watts used.” A middle school youth, when asked what messages s/he will take away from the carnival, wrote, “I can switch to CFL light bulbs, turn off computers when I am not using it, and let people know about it.”

Renewable Energy Technology. Other exhibits followed similar patterns but focused on different types of renewable energy technology. For example, one exhibit focused on the need for a new green LEED certified teen center.⁴ Similar to the light bulb exhibit discussed above, the four youth who designed this exhibit included a 3-D model of a proposed teen center that they made out of recycled materials, a Google Sketch Up image of the center, and a PowerPoint describing LEED certification and how it mattered in a new teen center. Their 3-D model showed a six room building, which included a large domed skylight in the center, on-site renewable energy, including solar panels and a wind turbine, sustainable site features, including native plants to help with water absorption and rain water collectors, energy and water efficiency devices, and recycled materials. Each feature was labeled under the relevant LEED category: Sustainable sites, water efficiency, energy and atmosphere, materials and resources, and indoor environmental quality (US Green Building Council, 2008). They also included the potential environmental impact of many of the features. For example, for the skylight dome, they included, “limit heat island effect” and for solar and wind, they included comments such as “have west and south facing windows for natural lighting,” “limit CO₂ emissions,” and “renewable.”

In the PowerPoint that they shared with visitors, they opened up with a definition of LEED certification (citing the US Green Building Council, 2008), and then turned their attention to what they referred to as their “considerations,” which included:

- What makes the center fun and useable?
- What do WE want in the teen center?
- What does Ms. T. (and other club leaders) want in the teen center?
- What makes the center GREEN?
- What level of green design (LEED) is achievable?
- What green features are realistic?

The PowerPoint then walked through various design components, such as the roof, the use of alternative energy, sustainable site and location, and so on. The youth running this exhibit leveraged their knowledge of LEED design and green building when creating designs for a new teen centers. This exhibit linked what the youth had studied the previous summer (green building design) with a new issue they were concerned about—the need for a new club building. These four youth spent many hours outside of GET City and official carnival planning time to complete their model and presentation because they felt, with the potential number of visitors to the carnival, they might find solid support for their idea. As Jana stated, “Building a new teen center will help the kids off the street and will help with contribution to the CO₂ emissions” (Planning document). The

youth felt that they could “hook” people onto this idea by presenting the problem in two ways: a safety and a sustainability issue. As they explained in their planning document: “show kids fighting on the street then show the impacts of CO₂ emissions (Show the animals dying, the floods from hurricanes, the polar bears dying & icecaps melting and oceans overflowing.). Then introduce green design.” (Planning document).

Through their design and explicit messages at the carnival, the youth connected the use of green energy technologies with decreasing human impact on the environment through decreasing the emission of CO₂. They shared their designs with visitors to help them understand the potential environmental benefits of LEED certified technologies as well as garner support for the building of a new teen center.

Other exhibits included renewable energy experiments and demonstrations (solar and wind), games, and an opportunity to decorate a backpack with their favorite green energy slogan. The carnival was filled with opportunities for visitors to actively participate in discussions of energy investigations connected to their local community. These exhibits left visitors thinking about the complexity of using renewable energy resources in Great Lakes City. For example, one elementary student wrote on the survey that, “you should use solar panels instead of other kinds of energy to help the Earth but the bad thing is you need the sun for it. You won’t have power for the days that the sun is not out, but still you are helping the Earth.”

Energy and the Environment. In the third message, the youth highlighted the relationship between the production of electricity and the health of the local and global environments. For example, in the “human power” station intended to make others aware of how much energy really went into making electricity, the youth set up a stationary bike attached to a generator designed to convert human power to electrical power. They asked participants to get on the bicycle and to compare the effort it took to power various types of light bulbs. They also attached the bike to an MP3 player so that attendees could power the music for the event with a playlist of what they viewed as “green songs” (such as Michael Jackson’s Earth Song). They shared a hand-crank flashlight and a poster that explained how electricity was generated by human power. In addition to examining force needed for electricity production, discussions at this exhibit dealt with the benefits of using alternative modes of transportation such as bicycles or walking to work or school.

Another exhibit focused on telling the story of coal, where, in their initial planning document, the youth wrote, “tell them about coal . . . and how harmful it can be, and give them information, and have a quiz.” The discussions at this exhibit allowed the youth in GET City to share expertise they had gained about the production of electricity in Great Lakes City (from experiences such as a trip to the local coal burning plant) by responding to visitor questions. In a group conversation after the event, the youth recalled the questions they were asked by the community participants. For example, Jana talked about being asked, “why can’t we reuse coal?” She said she responded by saying “it is not a renewable resource because it takes millions of years to generate. Everyone here will be gone and it still would not be re-generated.” Other youth talked about explaining that coal comes from “dead animals and trees and stuff like that and it takes a long time (to form).” We think that the questions they recalled from participants and their responses provides further evidence for how they thought about and understood the green energy framing of the carnival.

Critical Understandings of Multiple Dimensions of Place. Educated action involves both an understanding of science (previous section) and a critical understanding of place. To create and plan for a green carnival, the youth leveraged an understanding of the issues their community faced and the role of green energy could play in developing solutions to those problems. They also navigated among the people, discourses and resources of their community and of science in order

to design a green carnival that would be engaging, informative and successful. Below we take up two core claims that help to explain this point. First, the youth expressed a critical understanding of the multiple dimensions of place and how these dimensions position their community. These critical understandings were grounded in their positions as insiders to their community, and shaped how they understood and responded to others' perceptions of their city. Second, the youth leveraged knowledge of and concern for what people in their community knew—and needed to know—about green energy if their community was to thrive. We argue that both forms of understandings were driving forces that formed the impetus for youth to plan a green carnival.

The youth in this study exhibited a critical understanding of their place that drew upon layered understandings of the social, political, and economic dimensions of Great Lakes City. These lenses shaped how they talked about their city, and the role that their developing expertise in green energy might play in their city. Take, for example, how Angelica described the degree to which the depressed local economy, historically connected to the auto industry, has caused many families financial hardship and pain, including hers:

I already have two friends that have left Great Lakes City just because of jobs and stuff. And because they don't like it and don't have a lot of activities or entertainment, and I was pissed off about that. I grew up and was born in Great Lakes City, so I was pissed off about that. It is really tight, as my mom would say, because I actually listen to my mom because she needs help too. Anyway, their money is tight and they need it for food and for shelter and there is land out there so why don't you try to help them. At least try. Give them \$5 or something like that or money for them to survive . . . because some of them don't have a job because my dad got laid off. So some of them don't have a job and they need help, with money costs. They need help paying their bills because I have been looking at my mom's bills and whoa . . .

Angelica's comments emerged as part of a group discussion where youth were asked to describe Great Lakes City to someone who has never been there before. Her comments suggest that her understanding of place is complex and closely aligned with the people and social spaces that influence her life. While talking about her experiences in her city, she chose to foreground the economic realities of her family members and others living in her community. She later stated in the same conversation:

At the same time, people don't understand that because one, they haven't even been here. They haven't even been to Great Lakes City. For example, just an example. Florida. If someone is living in Florida and they have never been in Michigan, or Great Lakes City, if they say oh my gosh Great Lakes City Michigan is so boring—why would you say that when you have never been there?

Her statements above are in defense of her place while also identifying issues that impact the lives of those around her. Angelica's experiences and observations in her place lead her to an understanding of the social and economic conditions that members of her community are facing.

Similar stories were told by others in response to Angelica's comments. An important element of the youth's understandings of the multi-dimensions of place was in how they called upon their insider status to articulate both the positive and negative dimensions of their place and the nuanced layers between these determinations. Their insider status led the youth to be critical of outsiders who view their community negatively. We can see this in the anger Angelica expressed toward outsiders "from Florida" who may refer to her city as boring. However, a particularly telling episode from our data emerged during the conversation in which the youth debated what

others thought of their community. Jessie stated when asked what she would say to others about her community:

I would first talk to them about all the good things. I would talk about the bad things that happened here, but then I would tell them about all the good things that is happening here. I would tell them that we do have pollution, we do have some global warming and yes we do have a bad government and our economy is bad. But still we do have a lot of good jobs; we do have a lot of fun things to do here. People say Great Lakes City is boring, but I have been around the whole Great Lakes City area. I have been to the east, west, north and south side of Great Lakes City. I am just going to tell people don't just down Great Lakes City because you haven't been out enough.

Jessie's experiences have taken her to the four corners of Great Lakes City, experiences she points to as evidence of her insider status similar to Angelica. This insider status gives Jessie authority to speak about Great Lakes City candidly based on a real understanding of her place and the people who live in that place. In her comments she acknowledges the "good," the "bad," and the things that lie between. Jessie cares about Great Lakes City and is quick to point out that there are still many positive things about her community. However, what we also see in Jessie's comments is that her understanding of good and bad is grounded in her view of place that is intertwined among the social, political, economic and scientific dimensions of her place. In addition to economic and social issues, Jessie identifies global warming and pollution as additional issues she sees facing her community. She positions socioscientific issues connected to Great Lakes City as vital and relevant as evidenced by their inclusion in the "bad" things alongside economic narratives that often dominate discussions of Great Lakes City.

The youth leveraged these critical understandings of the multiple dimensions of place to frame how they might use their green energy expertise for helping the community. During one of the conversation groups, Jessie retold a recent local news story about how city budget cuts forced the closings of animal shelters. Jessie further suggested that GET City could put their green energy expertise to work to help out in response to these budget cuts. She stated:

You know what we should do, and it is something good for the community too. . . What we could do is have a *carnival* and either donate the money or take the money ourselves and buy them CFL's and green things for their electricity. . . Because of how bad our economy is—they are not helping the things that really need to be important.

Jessie's comments set the stage for what ultimately became the green carnival. Their initial talk in describing Great Lakes City, identifying issues in Great Lakes City and proposing solutions, represented the complex ways in which they view their place and implicated their science expertise toward making an impact in their community. In a conversation after the carnival, Jessie reveals several aspects of green energy she hoped visitors to the carnival would have learned. These included "how much coal we use and how bad it can be if we use it all," "how much money, electricity and pollution we could save from using less coal" and "how we should ride bikes more instead of riding in a car for good exercise or a good use of gas." These learning goals for carnival visitors are connected to issues of "global warming" and "pollution" she identifies in her description of Great Lakes City and are a result of her understandings of both energy-related science as well as her place.

It is these understandings of the multiple dimensions of place, grounded in their insider status, which initially give rise to the stated need for a green carnival—to do something "good" for the community. What "good" meant to the youth was as nuanced as their critical understandings of

place. As evidenced by Angelica's and Jessie's comments shared earlier, and the exhibit designs described above, good meant helping to raise money for their community in these economically challenged times. Good also meant helping others to save money by learning about energy efficient practices. Good also meant taking steps to impact the environmental health of their community. Lastly, good meant changing people's perceptions of what happens in their city. After the carnival, one of the youth, Chantelle, stated that, "the news should have been there because they are worried about everything else. You want kids to do stuff, and you are not even here to see us. . . I think it would be good for the community [to have seen the Carnival on the news] to see, wow, good job kids. Because the kids did it."

How the Youth Leveraged Understandings of Science and Place Toward Educated Action as Insiders Through the Green Carnival

The youth's desire to take educated action comes in part from the ways in which their insider status shaped how they came to understand the intersections of science and community. The youth's understandings of the multiple dimensions of place opened spaces for them to identify issues within their community and how they saw green energy science as part of the solution. The status as insider supported youth in understanding what people in their community cared about, and how green energy issues mattered to these ideas. As insiders the youth had a nuanced understanding of the social dimensions of place, which shaped how they framed what others should know about green energy. As discussed earlier, the youth had intimate knowledge of the "good" and "bad" of Great Lakes City. They also understood that their city was made up of many different communities, each with its own feel and needs. As Tami stated, "There are different types of communities in Great Lakes City"—there are "close knit," "bad," "downtown," and "rural" communities all in the same city (conversation with Tami and Maya). In particular, they described their particular community, as quiet and close-knit, and also serving many people who struggled to pay bills and find jobs. Their attention to the specific needs of their own community sharpened their messages for the carnival.

As the youth planned for the green carnival, they relied upon their insider understandings of science and place to guide the energy-related messages they would create for their various visitors. We see this insider understanding playing out in at least two ways: (1) Recognition that there is a lack of productive green energy discourse in their community, and (2) recognition of the importance of audience and the range of concerns they bring to the topic.

Green Energy Discourse in the Community. The youth expressed a concern toward the lack of talk around green energy in their community, and (mainly as a result of this awareness) they also expressed a desire to talk about green energy, and to take educated action in ways that helped to position people in the community as a part of the green energy *problem* and *solution*.

For example, with respect to awareness, the youth repeatedly made statements about what they thought people at school or in their community knew or cared about. In a representative statement, Maya, a 5th grader, stated in a planning session, "Well, some people in my school don't even know stuff is being wasted and why we are doing stuff like this. . . They could be doing stuff now and not really caring but when the world ends then they will care about it, but it will be too late. So we should try to change our minds now before stuff happens." Maya is pointing to the energy and environmental science knowledge and practices she believes her peers are not thinking about through observations of behaviors and discussions of ideas at her school. Energy issues have become important to Maya and she sees a need to make sure these ideas are discussed and deliberated upon with others due to an observation of what is missing for her peers. Her comment is directed not at only changing behaviors, but also helping others understand the rationale behind

these changes or “why we are doing stuff like this.” Her interaction with her peers provides insights into the knowledge and practices they have yet to consider.

The concerns about a lack of uptake of green energy concerns in what their peer group and community members talked about led the youth to want to do things that helped their community members to see how they were an important part of both energy-related problems and solutions. We share a detailed example, to show the intricacies of how this played out. Maya and Angelica spent several weeks finalizing a movie they made focused on energy technologies and behaviors in everyday life.⁵

The movie opens with pictures of coal burning power plants as Michael Jackson sings “look what we’ve done to the world” in the background. The images juxtaposed with the music reflect an understanding of the environmental impact of coal harvesting and use in electricity production. Next a series of questions flash onto the screen; “How much energy are you using?,” “Do you leave your light on when you’re not using it?” and “Do you leave your computer on when you are not using it?” By asking about what “we have done,” by showing the local power plant, and by incorporating a song by a popular singer and songwriter among their peers, the girls immediately position the viewer as responsible for their actions and insert the viewer into the green energy discourse. They also show that they are aware of their own contributions to the over use of electricity.

As the video continues, the girls take up these questions through an energy investigation at their local school, a site familiar to visitors of the green carnival, as the school sits adjacent to the club’s property. The girls first interview teachers about classroom energy behaviors. They hone in the role of phantom power, and suggest they have “a job for a student to make sure to turn off all computers and monitors at the end of the day.” Through situating their video in a familiar place, the girls show that actions at the local level matter, including developing robust understandings of one’s role in the problem. The girls also highlight the importance of gathering data to understand your own energy usage, and that kids can make a difference in their schools and classrooms through the actions that they take.

Next, they connect energy usage at schools to both local and national economic concerns by sharing “U.S. schools spend close to \$6 billion a year on energy” followed by a segment of an energy audit they conducted on the school with the district energy manager who connects the issue of energy costs to the local school context. Next, the video shifts to energy technologies that speak to this problem both in schools and home, specifically focusing on switching to CFL light bulbs. They show interviews they conducted with members of the community asking, “What are CFL light bulbs?” and “Why would someone use these light bulbs?” This is followed by a description of the merits of CFL light bulbs including that they “only use 23 watts where a regular light bulb uses 60 watts!” They go onto explain that “watts is a measurement of electricity and using less watts saves energy.”

In this segment, they break down the solution into two components that can be easily understood by the everyday layperson, without shortchanging the science. They explain both the technological and the behavioral changes that can help humans to mitigate the role of energy consumption on environmental impact. The girls exhibit an understanding of how we can measure energy usage based on power requirements of appliances as well as an awareness of the role of energy technologies in mitigating the electricity usage problems faced in their community and country. They indicate the importance of straightforward changes that everyone can make, such as assigning new roles in the classroom and at home such as energy monitors.

The video ends with Angelica telling a story about how changing energy behaviors and technologies “changed my grandmother’s life.” Her grandmother “got her energy bill and it was so high, she almost lost her mind.” Angelica explains that through changing her energy behaviors

and switching to CFL light bulbs, her grandmother saw a decrease in her light bill and was able to spend the money “on the things she really needs.” The video ends with the girls posing the question, “So what can you do?” to viewers and then reviewing changes in behaviors and technologies outline in the video including “changing to CFL’s to save energy because it uses less watts.” After green carnival visitors watched the video, they answered questions about the amount of energy different light bulbs use, what they learned from the video and what they could do at home or school to win prizes. This last scene shows how this is everyone’s problem and everyone’s responsibility.

The video offers a rich portrait of how the girls have leveraged their knowledge of science and place toward taking educated action. Their status as insider—in their families and in their schools—provided a context in which they could tailor their message in personally salient ways that would help the viewers also become insiders to the green energy issues they face.

Audience and Concerns. The youth’s insider understandings of science and place shaped how they made sense of and responded to what they thought different community members cared about and needed to know with respect to green energy. Tami, a 6th grader at the time of the green carnival, talked about the messiness of this process when asked about the challenges of preparing for the carnival:

Another challenge that we face is deciding what the message [of the green carnival] is going to be because there are a lot of things we can talk about green energy, but for certain settings we have to talk about certain things. Because other things might not attract people and attract other people so we have to figure out our message for that specific person or community.

In the above quote, Tami uses her insider position to engage in thinking about how she can present green energy messages to others in ways that are attractive—in ways that may impact their understandings or behaviors. She represented this idea at the carnival through her presentation of initial designs to build a LEED certified teen center at the Boys and Girls Club, which was discussed earlier. Tami and three other GET City youth explained green features of their design including “skylights for natural light and heat,” “on-site renewable energy sources” (solar and wind technology), “installing a green roof,” and “using energy efficient windows” (LEED video created by Tami & Janna), speaking to their understanding of green design and LEED credits they had learned in preparation of presenting their design to the board of directors at the Boys and Girls Club. However, these girls leveraged more than their knowledge of energy-related science as they created designs for a new teen center. Although the Club director had mentioned a new center as a possibility, the youth understood construction of a new building in Great Lakes City would require economic resources. In their planning document, youth wrote one of the potential outcomes of their exhibit was to “raise money for green room at teen center.” They saw the green carnival as a space to garner support from adults in the community about the importance of investing in a LEED certified teen center. Additionally, they foregrounded green building technologies that would impact monthly energy bills as well as the environmental health of the local community. They believed both of these economic aspects, in addition to their understanding of the relevant science, would speak to the board of directors at the club who were ultimately responsible for making the final decision on the teen center.

The board of directors and other adults weren’t the only audience Tami and the other girls considered in their designs. GET City youth also wanted their peers to see these designs and get excited about the potential of the new space. The group was responding to an issue they saw in the community regarding the lack of places for teens to come together in a safe and enjoyable space

while still being environmentally responsible. In the green carnival planning document, the youth wrote, “make it just for teens and make it bigger (and) less boring that it was in (the previous teen) room. There will be a kitchen, a game room and gym. (It will be) a miniature boys and girls club space but for teens.” Their plan for their exhibit represented their ability to speak to different audiences and desire to get these audiences excited about the potential of building a LEED certified teen space.

As described earlier, the intersections of economic and environmental concerns mattered particularly to their families, a main audience for the carnival. These concerns led the youth to plan a set of activities around energy efficiency and conservation that addressed both economic and environmental issues. For example, during one planning activity, Jessie returned to the light bulb investigation of a local elementary school her peers had conducted the year before as an example of how teaching others about energy efficiency might help to save money. She recalled how her peers had calculated that a simple shift from incandescent to CFL light bulbs in their school’s bathrooms would prevent 31,490 pounds of CO₂ from being emitted into the atmosphere as well as save the school \$2,278 in operating costs. This reflection began in connection with how GET City youth might respond to the crisis local animal shelters faced but then grew into how green energy understandings could impact the larger community. Jessie expressed a desire to help those in her community who she perceives as hurting and believes “buying them CFL’s and green things for their electricity” is a possible pathway to making a difference both to their bottom line as well as the environmental health of her community.

In addition to economic concerns, youth were also concerned about the environmental health of their community and Earth as evidenced by Maya’s previous comment regarding what her peers weren’t aware of and the potential ramifications of this lack of knowledge. Living in Great Lakes City, the youth are constantly reminded of the environmental issues that arise from the production of electricity in their community. The smoke stacks of an old electrical plant that will be decommissioned in 2015 due to changes in emission standards sits as a backdrop to many of the youth’s homes and was included in many of their videos they produced over several years. For them, it has become a symbol of the relationship between electrical production and climate change and environmental health. As Tami and Chantelle stated in a video shared at the green carnival:

Chantelle: In Great Lakes City, we burn coal to generate our electricity.

Tami: Have you ever seen those smokestacks? (followed by a photo of the local power plant). Not only do they give us pollution, but they also release carbon dioxide.

The youth planned exhibits in response to these articulated concerns. For example, in response to what they know about electricity production in and for their community including the potential environmental impacts, the youth decided that they wanted to have two exhibits around the story of electricity to sit side by side at the green carnival. One station would tell the story of coal, where in their initial planning document they wrote, “tell them about coal . . . and how harmful it can be, and give them information, and have a quiz.” The other station would be a bicycle connected to an electrical generator and MP3 player in order to power music for the carnival in an environmentally friendly way. In the passport given to visitors to document their travel through the carnival, the youth wrote that visitors would, “generate electricity using human power” and answer questions regarding the environmental benefits of using sources other than coal for electricity. Further travel through the carnival would introduce visitors to possible alternatives such as solar or wind energy for them to consider in terms of environmental impact of electricity production.

All of these examples from planning for the carnival reveal how the intersection of their developing knowledge in green energy and place-based understandings provided space for the youth to take educated action by designing messages for visitors that addressed their key audiences' concerns.

The Forms of Educated Action and How These Forms Were Responsive to the Connections Youth Made Between Science and Place

In this section, we argue that the specific design of the carnival itself was intended to make green energy issues accessible, salient, and interesting to the community in response to how they understood their community's knowledge of green energy. We believe that these forms of educated action allowed the green carnival to open dialog and foster interaction within science among community members.

Making Green Energy Accessible Given the Constraints Posed by the Multi-Dimensions of Place. The youth desired to create a green energy space that was inviting to members of their community and was fundamentally participatory. The term carnival was an explicit choice by the youth. They imagined and implemented a place that was filled with playfulness, enjoyment, and entertainment. They desired to teach their community about green energy ideas and practices in an environment that blurred boundaries between science and all that is not science.

There were three strategies the youth deployed to foster accessibility: interactive exhibits with direct links to the community, providing tools and resources for making changes, and juxtaposing serious science messages with playfulness. The youth organized exhibits at the Carnival to allow people to choose what green energy ideas they wanted to explore by providing opportunities to engage with many different aspects of green energy and encouraging people to move freely through the exhibits. The exhibits were interactive and designed to teach concepts in ways that connected to local practices and concerns while keeping an eye on a better future. For example, at the light bulb station participants could measure how hot an incandescent bulb was compared to a CFL, talk about the idea of home energy efficiency and then take free CFLs for use in their home. At the solar energy station, youth not only talked about the benefits of solar energy in general, but also opened discussions with visitors if this technology was an answer for Great Lakes City. This discussion was informed by a trip to a local solar array where youth found out due to efficiency issues with the technology and environmental factors of Great Lakes City (i.e., lack of sunny days), the array was only powering eight homes. This information as well as an understanding of the cost of the technology caused youth to question whether it was an avenue to address energy issues in Great Lakes City.

Additionally, the youth increased accessibility by explicitly attaching tools and resources for making change with each exhibit. We see this with the free CFL's in the previous example or with the dialog and materials around how to use solar energy in their community. We also see desire to provide resources in their plans for the game station. As Jessie and Chantelle wrote, "We will have games and whoever wins will get light bulbs, a bag of candy, or a pencil and a pad (both are green and we can write "Get City" on all of the pads)." The youth used the carnival to attend to what might be possible, such as the building of a green teen center and getting community feedback on their initial plans which was important to these youths who were budding teens themselves.

Lastly, the exhibits' descriptions juxtaposed serious topics and rigorous investigations with lighthearted activity. Information and quizzes on the role of coal in our energy system were followed by games, candy, balloons, and dancing. These ideas were repeated in the many iterations of planning as Jessie and Chantelle wrote on later planning document: "We are going to have carnival games and there is going to be an entertainment place for anyone who wants to sing if

they want to and if they sing or dance they get something like a bag full of Get City pencils and notebooks and candy.” They also planned to have a stage with entertainment. As they wrote, “Stage (note: This can be just a table with some balloons so we don’t spend a lot of money)—like a deejay, and then people can possibly sing, and dance in front with a curtain behind it.”

These planning ideas revealed a vision for a green carnival that granted visitors the freedom to tour the exhibits at their own leisure. Visitors were also allowed to survey or investigate energy ideas in nontraditional ways while being given real tools at each station for making a difference in their community.

Opening Dialog: Green Carnival as a Space for Changing the Relationship Between Science and the Community. Participation from community members was vital to the design of the event. If we look closely at the passport the youth created, we can see how the passport itself positioned participants as active contributors to green energy practices and as people with experience and knowledge that matters. Each one of the exhibits asked participants to do something and to bring their own experiences and ideas to bear.

For example, as described in the previous section, the video referenced above and shown at the green carnival was created by Angelica and Maya and aimed at educating community members about sources of electricity production, how energy use is measured and how energy use impacts environment conditions. Angelica and Maya connected expertise gained in energy-related science with expertise they brought with them regarding the social and economic concerns of their community. While the video focused on economic benefits of CFL light bulbs and various energy-related behaviors salient to the community, they added to this dialogue by introducing an understanding of the relevant science behind these technological advances and behavioral changes. Angelica and Maya believed this was the best way to engage and educate their audience. In this example, science was a part of a solution to problems they saw facing their community. Science was another dimension of their place to be considered along side those they bring with them from other experiences.

While the atmosphere of the carnival was designed to make energy-related science accessible and enjoyable for visitors, the youth also had a desire to push visitors to interact with new ideas around energy-related science. Jessie talked about her desires for the carnival in an interview after the event: “I wanted them to try and learn something. I wanted them to kinda like—oh, I didn’t know this or I should try to do this more. I should stop doing what I used to do and start helping more so that the world could be around longer.”

The youth wanted the science they were learning about to be meaningful for their audience. Implicit in Jessie’s comment above was her hope that each visitor would walk away with a new understanding of energy-related technologies or behaviors that could lead them to take educated action for themselves.

Chantelle also reflected this idea in her poem included in the greencarnival flyers.

greencarnival
Earth Day is coming April 22nd!
And the sun is rising
People are waking up

The statement that people are “waking up” reflects the importance Chantelle saw in the messages and how the goal of the green carnival was to open dialogue with visitors about energy-related issues with hopes of inspiring action.

In short, the youth leveraged their critical understandings of place and insider status as an impetus to take educated action by identifying local energy-related issues and preparing messages for multiple audiences. They also leveraged their growing science expertise throughout the planning process (both in identification and planning educated action) as they took up the complicated work of merging science and place. This intersection of science and place-based understandings led youth to create a space that opened dialog on changing the relationship between science and community. While the youth believed they had something important to add to this conversation, they also understood and made space for members of their community to share what they wanted to contribute to these conversations. There was an understanding that in order to have a conversation, more than one voice or one group's voice should be heard. The green carnival would not have been the event the youth believed it was without participation from over one hundred visitors and an understanding that their participation meant more than receiving knowledge from an "expert" group. These areas of expertise leveraged by youth all mattered because the socioscientific issues they identified are complex, involving many aspects of their place including the economic, political and social dimensions as well as environmental and ecological sciences. It also mattered because these areas of expertise allowed youth to take educated action in and for their community that they believed would make a difference.

Discussion

The work of youth in planning and enacting the green carnival raises important questions regarding the role of educated action in fostering the development of scientifically literate citizens. We began this paper by arguing that despite attention to the role of science literacy for democratic participation in reform initiatives, educated action continues to play a minimal role in science education due to policies grounded in the idea that scientific understanding is enough to prompt informed and reasoned action (e.g., AAAS, 1989; NRC, 2012). We see the role of educated action further minimized by a lack of consideration in the science classroom for the political, economic and social dimensions of issues and students' connections to them (Bowers, 2002) when bridging science with civic engagement.

We believe the educated action taken by the youth in our study speaks back to these issues in two important ways. First, the youth reveal their impetus for taking educated action, or being civically engaged with science, required *more than knowing* the relevant energy-related science. Educated action also required a critical understanding of their place and how these understandings intersected with science in meaningful ways. Second, the youth's educated actions altered the relationship between science and community, and in so doing these youth shared a vision of what it looks like to be civically engaged with science. This vision incorporates the multidimensional aspects of place and challenges the historical positioning of low-income and minority communities as outsiders to science. This vision stands in contrast to the literature that suggests that citizens often neglect scientific knowledge when making decisions on courses of civic action (Allum et al., 2008; Sadler, 2004). It also stands in stark contrast to the literature that suggests that youth from lower-income and ethnic minority backgrounds view themselves apart from science. We discuss these two points in greater detail below.

Impetus for Action

We argued that through their work preparing for, planning and implementing the green carnival, the youth expressed a critical understanding of the multiple dimensions of place and how these dimensions position their community. These critical understandings were grounded in their positions as insiders to their community, and shaped how they understood and responded to others' perceptions of their city. Second, the youth leveraged knowledge of and concern for what people

in their community knew (and needed to know) about green energy if their community was to thrive. We argue that both forms of understanding were driving forces that formed the impetus for youth to plan a green carnival.

However, the youth also revealed that taking educated action is not implied simply because an individual or group possesses the relevant knowledge or practices. A component of educated action involves a desire to take action inspired by relevance or care for the issue being investigated. An individual generally does not take action based solely on an understanding of a concept devoid of relevance to their community, life or idea they personally care about. The green carnival did not happen simply because the youth were learning about and gaining expertise in energy-related science. Instead, it was through opportunities to find meaningful connections to relevant issues in their community that the youth decided to do something to “make a difference” in their community. Thus, we conceptualize educated action as requiring more than knowing, but also the desire to do something with that knowledge. For the participants of this study, the desire came from grounding the investigations in critical understandings of the multiple dimensions of place.

Integrating Science and the Community

We find the youth’s efforts to open dialog in ways that are accessible to their community particularly salient because it challenges the stereotype that lower-income or minority communities are somehow disinterested in science.

We are drawn to Bakhtin’s writings on carnival/carnavalesque to make sense of the event (Weinstein & Broda, 2009). Bakhtin (1984) has written about carnival as a cultural activity that breaks down the social hierarchies of everyday life through undermining oppressive routines, suspending normative and prescribed ways of interacting, talking and being, and upending authority. The youth who thought up, designed, and enacted the green carnival are from lower-income and ethnic minority backgrounds. These are the very youth that dominant narratives in society state are not interested in science, capable of high level science, or civically engaged in their communities. The green carnival provided a public space to upend these narratives—to position themselves as the caring, committed experts that they are. At the same time, how they designed the carnival, supported the youth in encouraging their fellow community members to also be interested in and to take action around the socioscientific issues that shape their lives.

We argue the youth altered the relationship between science and community in Great Lakes City through opening up new spaces of participation for visitors based on their ability to merge what they had learned about energy-related science with what they know about their place (Nolin, Bragesjö, & Kasperowski, 2006). The youth valued the community experience of visitors in the kinds of dialog on green energy they fostered at each exhibit, challenging what constituted authority in the context of becoming a green science expert and how one is allowed to participate in the discourse of green energy. However, unlike Bakhtin’s carnival, where the breaking down of social hierarchies sits within a confined time and place, we see the youth’s educated actions as tracing a new way of being in their community. However, the carnival itself, provided a safe space to test these new ways of being and doing in the community.

Having opportunities to incorporate multiple dimensions of place as well as growing scientific expertise created and supported meaningful learning opportunities for youth. Gruenewald (2008) argues, we “are not only shaped by places, but we are place makers, and what we make of our places, and the character of the places we leave behind over generations reflects much of our political and cultural lives, as well as our theories of knowing and doing” (p. 144). The insider status of the youth exhibited during the green carnival mattered because it legitimized ways of knowing that are fundamentally important to how science could be constructed as both knowledge and practice in Great Lakes City. Youth working as an insider in their place allowed

them to alter what it meant to do science in Great Lakes City and who is capable of doing science. In many ways, as they took educated action through the green carnival in their community, they acted as “place makers” by opening space to think about the ways in which science knowledge and practices are meaningful in Great Lakes City that had been historically absent. The concerns of their community were considered along side the knowledge of energy-related science blurring epistemic boundaries. It was not simply that youth brought knowledge of their place to these investigations and educated actions, it was that this knowledge was valued and legitimized within the group and community that mattered. The economic conditions of Angelica’s family and friends or the political, economic, and scientific issues Jessie saw in Great Lakes City through her critical connection to place mattered to these youth and was legitimized through interactions with community members.

In short, we believe youth altered science/community relationship through positioning science as accessible, relevant, important, and fun by opening up new and different spaces for participation by community members. This work is a significant aspect of the educated action they took through the green carnival. These youth and their participation with science help us further see how place and the position of “insider” influences interactions with science knowledge and practices, allowing the relationship between place and science to be altered in the ways described above.

Conclusions and Implications

We have argued throughout the central role critical understandings of place assumed in being the impetus for taking educated action and thus learn more about the relevant science. The youth opened dialogue with community members by breaking down social hierarchies in terms of who can do science and when, where and how science can be meaningful in the lives of people in Great Lakes City. They suspended normative and prescribed ways of interacting and being, barriers that often keep people out of science. The youth relied upon their critical understandings of place as an impetus for educated action legitimized through their status as insiders allowing the creation of new forms of epistemic authority. In addition, these youth leveraged their critical understanding of place and insider status to access community dialogue around energy-related issues to construct green energy messages to expand this dialogue.

The youth in this study show the power of situating investigations through place as well as providing opportunities for youth to leverage multiple areas of expertise to take educated action on socioscientific issues. As educators, we need to continue to examine the role educated action on relevant socioscientific issues can and should assume in science education and the ways in which opportunities are provided for youth to take educated action in both formal and informal science learning contexts. We discuss both implications below.

Informal Spaces and Educated Action

Informal educational spaces offer a unique environment in which to think about both the role of place and educated action in science education. Those who argue for the power of informal science learning attribute the success to aspects such as choice (both of topic and level of participation), connections to real-world problems and introduction to science-related careers (Bevan et al., 2010; Falk & Dierking, 2002; Fenichel & Schweingruber, 2010; Granger & William T. Grant Foundation, 2008; Weinstein & Broda, 2009; NRC, 2009). The Harvard Family Research Project (Weinstein & Broda, 2009) argues informal science learning provides “expanded learning opportunities” that go beyond the content, bringing in the learners’ interest, and relationships built with peers and adults as they investigate science-related ideas. The aptitudes that may be gained transcend the canonical view of science literacy and enter areas of motivation and social action through experiences with science in the informal sector. This is a view of learning science that

incorporates both knowing and doing, which values different aspects of participation, ways of knowing, and intended outcomes. These experiences allow learners to take on identities that otherwise may not be available to them through traditional normative science education. We see this through participation of GET City youth as they worked tirelessly to gain the relevant knowledge and skills in order to put on the green carnival for their community. They were not motivated by grades or completing an assigned task, but by the opportunity to take action and share expertise with others.

We believe educated action on socioscientific issues is a responsibility of citizens in a democratic society and thus an important goal for science education. We see informal education as an avenue to provide opportunities for youth to take educated action today on relevant local issues and thus support their development as scientifically literate citizens. The work of these youth in designing and implementing the green carnival is just one example of how informal science learning can support youth in taking educated action.

School and Educated Action: Turning to the Next Generation Science Standards

We are also interested in and see possibilities for youth to take educated action through their formal schooling. We turn to the Next Generation Science Standards (NGSS, 2013) that break formal school science experiences into three major areas; practices, cross-cutting concepts, and disciplinary core ideas. The inclusion of practices reflects a belief in the importance of doing science in addition to gaining an understanding of the concepts. However, doing science is framed as important in order to gain an appreciation for how “science knowledge develops” with the idea that once understanding is achieved (sometime in the future), “students may then recognize that science and engineering can contribute to meeting many of the challenges that confront society today” (pp. 42–43). We expand upon how we see doing science represented in the standards document below.

First, there is a temporal aspect to what youth can do with science represented in the standards. The authors’ state the goal of NGSS is to outline “what all students should know in preparation for their individual lives and for their roles as citizens in this technology rich and scientifically complex world” (p. 10). This statement positions school as “preparation” for future lives as citizens in order to understand and make decisions in a “complex world.” Taking educated action is thus a future endeavor, something that is accomplished once school is over, science knowledge and practices are understood and life as a citizen commences. While students may be encouraged to be active learners in the pursuit of scientific thinking and practice, they are positioned as passive with respect to acting on that knowledge to engage with relevant real world problems. In other words, science knowledge and practices are an ancillary benefit that we hope youth will “recognize” once they understand the ways in which scientific knowledge is generated.

Furthermore, the concerns we raise here are more expansive or cross cutting than the espoused view that it is important to “connect to students’ interests” in the hopes of broadening participation in science or that children bring “diverse customs and orientations” to science learning contexts which are “assets on which to build” (p. 26). While fundamental to equity concerns (see Chapter 11 of the Frameworks, NRC, 2012), we argue that educated action, and the role of place in how and why youth formulate and take educated action, is about more than acknowledging youth bring a wide range of cultural knowledge and experience to the classroom that shape their learning and participation in science. Engaging how and why youth formulate and take education action is part and parcel of creating opportunities for “students to develop meaningful understanding, to actually practice science and engineering and to reflect on their nature” (p. 25). It reflects both an outcome of learning science in terms of learning to use understandings and practices in the here and now, as well as reflecting a process for how children learn science.

We are not suggesting that the new science education standards in the United States do not attend to the value and importance of engaging science in everyday life in the complex and place-based ways that the youth in our study have done. What we do suggest is that the very idea of educated action is absent from the frameworks, but yet essential to how or why youth might engage deeply in scientific ideas and practices in the moment and in their futures. We believe educated action belongs as a part of the standards guiding current initiatives in science education in the United States. We argue that the ways in which youth's critical understandings of place provide insider tools to contextualize and personalize scientific knowledge and practices in ways that foster real engagement in science is fundamental to meaningful learning.

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Notes

¹All names of cities, schools, and students in this paper are pseudonyms.

²<http://getcity.org/blog/2011/04/28/get-city-green-carnival/>.

³http://getcity.org/getcity/Home/Entries/2010/2/26_Make_that_Change.html.

⁴Leadership in Energy & Environmental Design (LEED) is an internationally recognized green building certification system that requires third-party verification that “buildings and communities are designed, constructed, maintained, and operated” using strategies for improving energy performance and sustainability (<http://www.usgbc.org/leed>).

⁵<http://getcity.org/blog/2011/04/28/the-green-carnival/>.

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