Youth Authored Multimodal Digital Video:

Expansive Learning, Counterstories, and Critical Science Literacy

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Abstract

Youth participants in an informal after school science program created a multimodal digital video public service announcement video. This paper considers the counterstories that emerge within the video and during the making of the video that challenge existing definitions of science literacy. The investigation suggests youth engage in expansive learning where vertical knowledge and horizontal knowledge inform their actions toward community based energy issues. Vertical knowledge describes the scientific knowledge youth engage while horizontal knowledge refers to the locally situated knowledge necessary to move between communities. I argue that youth counterstories and expansive learning are key elements of critical science literacy. Critical science literacy takes place when science is transformed in ways that allow traditionally marginalized individuals to gain power and agency to oppose the forces of marginalization and strive for justice.

Keywords: informal science, multimodal video, expansive learning, counterstories, critical science literacy

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> Michael Jackson's *Earth Song* can be heard as a video clip from a student made public service announcement plays. The song lyrics ask, "What have we done? Look what we've done". An image of a large mine appears with text declaring, "This coal mine used to be filled with trees and grass." The music fades and we see Chloe ask the viewer, "Have you ever seen those smoke stacks?" Her voice and image give way to a picture of a power plant with the text "LANSING'S ECKERT COAL PLANT" layered on top. The next image shows three stacks with billowing smoke with an ominous burnt orange hue as the camera zooms in tighter and the music fades forward asking "What about flowering fields". The same image of the mine reappears but the now text reads, "This land and our atmosphere may NEVER be the same."

The vignette comes from a youth authored video that was created in an after school informal learning program during the 2009-2010 school year. I, along with my colleagues, worked with a group of twenty youth (ages 10-14) to investigate the newly introduced statewide policy initiative ("Change a light, change Michigan"). From this point forward, I will refer to racially non-White participants, and in this project African-American as *youth of color.* The primary goal of the unit was to engage youth in thinking deeply about the broader ideas of energy consumption and environmental impact, and how detrimental impacts can be positively

impacted by both behavioral change (energy conservation) and technological fixes (energy efficiency) especially at the local level. Over the course of the initial unit (12 weeks in the fall & early winter), youth conducted experiments, interviewed experts, and engaged in debate on broader issues related to energy efficiency and conservation including: how electrical energy is produced, the problems associated with the use of fossil fuels, including carbon emissions, and how energy consumption is measured and mediated. The unit culminated with youth being asked to create a public service announcement (PSA) on the importance of energy efficiency – their goal was to create an artifact that might speak to the "Change a light, change Michigan" initiative.

However, one group opted to ground their PSA in the real life issues faced by their school and caused a shift in the audience for the collective set of PSAs. The over reliance on incandescent light bulbs in an age of budget cuts became the central issue that led to youth to conduct a thorough light bulb audit at their school and to build their PSA around it. Instead of crafting knowledge-oriented documents for a generic audience, the youth collectively decided that their products could and should be used to educate their school community. The youth also recognized how their families and church communities could benefit from learning about energy efficiency at home. As one student said when asked why this was important, "CFLs save money because regular light bulbs take a lot of energy. This means that you pay less money and you are not burning as much energy or coal to make the electricity."

The youth crafted a "workshop" for their peers at school based around their artifacts. I was very interested in what youth decided to put into their artifacts meant to educate others – what messages did they craft – about the content of the energy efficiency unit, about why these ideas matters within the community context, and who they are as community science experts? The youth repeated the workshop at the club where the program is hosted, at their churches and at a local community center. The youth took actions through the workshops and also by distributing CFL bulbs to the community and started by swapping out incandescent bulbs in their own homes.

In this study, I wanted to take a critical eye toward how a group of middle school youth framed the real-world, real-time problem the present day call for energy conservation and efficiency in their state, and their place in the broader narrative. I am most interested in how youth engage in science in the community setting.

The manuscript, therefore, has a dual focus: First, I am interested in making sense of what youth position as important knowledge for others to have about energy and the environment, and how they position themselves as science experts (users and producers of science). Second, I am interested in outlining a systematic approach to analyzing youth authored videos for instances of and how they represent their knowledge in digital video products through their messages within multimodal environments.

The goal of this investigation is to answer the following questions:

1. How do youth use self-authored multimodal video as a tool to engage the community in science?
2. What counterstories are present in the multimodal digital artifact?

Conceptual Framework

The research is grounded in two bodies of literature: counterstory and expansive learning theory. The framework builds an argument for why it is important to make sense of how youth of color articulate what they know with and in the broader sociocultural narratives, and how they position themselves as powerful knowers and doers of science.

Angela Calabrese Bart..., 12/6/11 6:29 AM
Comment: If they are all African American, then just say that?

Calabrese Barton & Tan (2010) have argued that having opportunities to engage in real-world, real-time science problems alongside practicing scientists, when accompanied with further opportunities to educate others about this work, positions youth as community science and engineering experts. Furthermore, they have argued that becoming expert and educating others involves translating core scientific ideas and principles for individuals outside of the science community and with limited exposure or expertise in the discourse and practices of science, that it involves demonstrating how their design work and findings impact the local community, allowing youth to illustrate ideas in place-based ways, and offering steps for change and/or transformation. However what we need to know more about is how youth grapple with these real problems, especially when such real world and real time problems are ill figured and demand expertise that is not always neatly mapped onto the science and technology learning standards that are part and parcel of schooling.

Angela Calabrese Bart..., 12/6/11 6:30 AM
Comment: The connection between this paragraph and the next is not clear

I take a critical perspective and draw upon the work of critical race theorists to elaborate on counterstory. According to critical race theory (CRT), counterstories are the narratives told by marginalized people in a White dominant society (Delgado and Stefancic, DATE). Counterstories are often unheard in the mainstream grand narratives. Rather, they are relegated to the margins and often told within racialized populations of color. Yet, the value of the counterstory cannot be dismissed as it challenges the dominant narratives and offers an alternative to the systematically imposed power structures. In this work, I examined the power and agency contained in the counterstories of youth-authored multimodal video artifacts.

The dominant narratives in science spans many activities, including the narratives of what science is, who can do science, the materials and symbols that give structure and meaning to the discipline, and the norms for participation. Take for example the investigation into the experiences of youth of color in the urban northwest (Tzou, Scalone & Bell, 2010). These researchers followed a group of students who were involved in an after school environmental science program housed at a community center that served a significant Hispanic population. On one particular day they were going to the local farm to do community service and to learn about the role the farm played in the community. Upon arriving they noted people planting and tending to gardens. However, when they were greeted by one of the garden leaders, he spoke to the group in Spanish (positioning them with a particular identity) and explaining to them that their job that day was to use the wheelbarrows to haul manure. While fertilizing a garden is important task in the ecology of the garden, it was clear to the youth that they were positioned as "other" – as the hard laborers. One of the participants, however, commented on how the youth were positioned in the "stinkiest jobs", expressing how a dominant cultural-historical narrative that "linked Mexicans to doing hard labor—not only hard labor, but the "stinkiest jobs"—and the power dynamics that accompany that societal role" (Tzou et al, 2010, p. 18). For the youth in this study, having the opportunity to critically read the narrative of what it means to do science across racial and class lines was a powerful learning opportunity for challenging and changing these dynamics.

Counterstories in science can also question who can do science and what it means to author and challenge scientific authority. The subjectivities that youth bring to doing science shape how they seek to access the domain and the roles they take up. When the learning community fails to legitimize the identities that you bring, then opportunities for critical engagement are shut down. For example, Calabrese Barton & O'Neill (DATE) worked with youth dubbed as the Fabulous Five who used digital storytelling to engage in science and challenge prevailing ideas that the failing status of their school is representative of their abilities.

Specifically, the youth used digital stories to give themselves and their peers voice in an otherwise teacher-centered science classroom environment. The authors argue "that counter-storytelling is an especially important way to understand how urban young people choose to engage with science and how they seek to use science to establish their participation in society" (p. 142).

Critical engagement with science can serve as robust contexts and tools for participating in a democratic society in fair, just and transformative ways. By transformative we draw upon Freire's (1970) notion that education ought to provide opportunities to understand, challenge and re-create understandings of the self and the world. As a context, science acts as a set of conditions that allow youth the space to take up new identities and practices for tackling questions normally constitutive of others. For example, Fusco & Calabrese Barton (2001) worked with youth who have experienced environmental injustice because of where diesel bus terminals are located or because which abandoned lots their city may renovate. These environmental injustice contexts presented, in part, a science narrative that allowed students the space to bring their visions for a better neighborhood as a mode of critically engaging with science, as the youth turned an abandoned lot into a community garden. In other words, science becomes the object upon which they act through their lived experiences. This kind of critical scientific literacy implies that students use the knowledge, practice and context of these disciplines to develop empowering identities, to advance their positions in the world, and/or to alter the world towards what they envision as more just.

Angela Calabrese Bart..., 12/6/11 6:32 AM
Comment: OK, good way to weave this into counterstory….but I think you need to be more explicit with the counterstory connection

Expansive Learning

Engeström's notion of expansive learning is helpful for considering ways of thinking about learning that give insight into how students know/practice knowledge within the sociocultural and political contexts of their lives. Expansive learning refers to the way that two activity systems intersect at a zone of proximal development. The activity systems are found along what Engeström calls the horizontal and vertical dimensions of learning. Expansive learning occurs when a transformative learning process takes place at this junction. That is, when the established ways of knowing contradict alternative ways of knowing leading to a new activity system (Kimonen & Nevalainen, 2005).

Gutierrez (2008) has taken up Engeström's expansive learning theory but with a more critical slant to place focused attention on the role of everyday cultural practices. In her work, she uses the constructs of horizontal and vertical dimensions of learning to explore what it means for youth participants to become an expert. While the vertical dimension focuses on the science content, horizontal notions of learning focus on expertise that is developed within and across practices and communities (Gutierrez, 2008). In horizontal learning, the focus is on both the distributive nature of learning and the repertoires of practices that individuals cultivate as they move through space and time. Gutierrez' point is particularly important because little attention outside of equity-driven research has focused on how learning is informed and transformed by the sociopolitical dimensions that shape everyday activity and living, or how a sense of place complicates how and why youth come to understand their worlds.

I borrow Gutierrez's interpretation of vertical and horizontal learning in order to trace out what students bring to bear on the multimedia artifacts they created for these workshops. It provides a way to make sense of how the more traditional content storyline is embedded within and across the communities in which youth participate and in the ways that matter to them. I use storyline to refer to the ways in which science ideas and activities are woven together by the youth to construct a story in way that makes sense to them (Roth et. al., 2009). I sought to

identify the ways youth draw upon their science knowledge and context-based knowledge and how the two intersect as places of transformation that differ from other views of scientific literacy.

When considered together, counterstory and expansive learning bring together narratives that not only challenge the dominant discourses but also take into consideration the knowledge of youth of color for both the content-based science and insider knowledge of their lived world. How these are manifested in youth-authored multimodal video that oppose hegemonic ideas of who can do science, what counts as science knowledge, and are empowering for youth provide the basis for this study.

Angela Calabrese Bart..., 12/6/11 6:32 AM

Comment: Good attempt to bring the two perspectives together. I would like to see you do more with this, though not necessarily for the practicum. Also, I think this framing works better than the CSA and the expansive learning.

Context

GET City is a program funded by the National Science Foundation (NSF) designed to engage urban youth in learning around green energy issues and advanced digital technologies. The program is designed as an after school program where youth are deeply engaged in authentic investigations of green energy issues and in the practice of communicating their findings to their community in ways that bring about change. The youth voluntarily join GET City drawing a diverse range of racial and ethnic backgrounds including many youth of color. GET City meets after school at a local Boys and Girls Club twice a week. Once a week, the youth participate in activities designed by program teachers that address program objectives around energy. The youth have an additional opportunity each week for computer work time to extend their investigations of green energy and utilize digital resources for the development of a variety of youth created artifacts. The PSAs are an example of digitally based work produced by youth in GET City.

After school science programs offer the opportunity to engage youth in real-world, real-time problems, where they are positioned as science experts (producers of knowledge) as well as community participants (and consumers of the work). Unlike the rigid structure that school science often follows, GET City offers a hybrid space where youth can engage in green energy issues offering a positive academic and social environment where youth can access science. Through GET City, youth have the opportunity to come in contact with members of the community to both access knowledge and position themselves as experts through public community presentations showcasing their work, their message, and their knowledge.

The GET City team members served as program designers, teachers, and researchers. I joined the team, initially as a researcher, after the video was completed. The team was committed to providing youth opportunities to expand their knowledge in and practice of science, in ways that complements school learning, and positions youth as science literate citizens. At the same time, the team was keenly aware that youth come to doing science with their own culturally located sense making strategies that frame not only the meaning they make of the science under investigation, but also how they reason with evidence and communicate it with others. The team was further aware that because youth are working on real-world real-time problems, they are accountable to more than just the science learning community as they seek to build a compelling scientific narrative for others.

All three participants in this investigation are African-American females and they all attend the same middle school. The girls have been active participants in GET City for at least two years meaning they have had extensive experience engaging green energy issues and developing digital technology skills. Two of the girls, Chloe and Jocelyn, were sixth graders and both have older siblings that previously participated in GET City. Ayana is one year younger and in the fifth grade and all three are good friends. Chloe is a straight A student at school but she

has expressed that school science is boring for her. Likewise, Jocelyn is a strong student academically but unlike Chloe reports that she enjoys school science. Ayana struggled at times in school but worked hard to be a B student. Their school is adjacent to the Boys & Girls Club making it convenient to attend and also situates them as members of the local the community.

In this paper, I focus on the multimodal digital video product made by the three girls. As described in the introduction, the video was created as a public service announcement at the culmination of an energy efficiency unit. While other youth also produced videos, the LBA video was chosen for analysis in this study because it was the only one that used a locally situated investigation to uncover and present evidence as a way to influence audience members. Furthermore, the LBA video provided the best case for analysis containing greater substance as afforded by the length of the video. In the methodology, I provide a description of the video PSA.

Angela Calabrese Bart…, 12/6/11 9:28 AM

Comment: Later, for publication, I think you can make this paragraph much stronger. Instead of almost apologizing for the selection convince the reader that this is a powerful artifact that tells its own story…

Methodology

The *Light Bulb Audit*, a youth created video artifact, and interview with the youth were used in this critical case study of how youth made sense of green energy issues in their community. As a teacher and researcher in this program, I am keenly interested in what new meanings youth make of the scientific ideas and practices they encounter and take up as part of their investigations as well as the meanings they ascribe to them as they seek to make change in their communities.

What I sought to do here was to develop a methodology for how to make sense of the science content storyline in the multimodal video artifacts youth produced, with special attention to how that science content storyline: a.) provide evidences of meaningful understanding of key science ideas and practice ("developing vertical expertise"); b.) is embedded with particular messages and place-based meanings, values, and priorities that matter in their communities (developing "horizontal expertise"), and c.) challenges stereotypes of what science is and what it means to know/do science (how horizontal and vertical expertise juxtapose and transform the other). I recognized that youth are situated not only within the program but also in a larger contexts around school, neighborhood, and town. Furthermore, youth interact with individuals within multiple communities. I wanted to know how youth represented science within the videos and how they used scientific evidence to communicate to their audience, and how the videos serve as counterstories.

In addition to the multimodal video artifacts, I conducted a group artifact interview focused on youth science content knowledge and their ability to explain the storylines after time had elapsed from the time they finished making the PSAs. The three creators of the LBA were interviewed as a group using semi-structured interview questions. According to Glesne (2006), the group interview can provide multiple views on a particular topic or event and also serves as a form of member checking. In addition to these qualities, I chose to interview the youth in a group for two additional reasons. First, the youth co-constructed the video artifact so it was important to have all members on hand rather than conducting individual interviews. For example, I hoped the group interview would help youth trigger memory about the construction process that might otherwise be undiscovered in individual interviews. Second, as a relative outsider to the program at the time of the interviews, I sought to minimize the anxiety of the youth by asking to interview them in a group rather than in isolation.

The youth were given the materials used in a light bulb experiment and compared incandescent and CFL bulbs for energy efficiency. They were asked to explain the experiment

and allowed to set up the activity, test for watts used and heat of the light bulbs while illuminated. They also made visual observations of the brightness of the light bulbs (lumens).

In the second part of the interview, each youth was given a large poster size sheet of paper and a set of ink markers. They were given directions to draw coal on one side of the sheet and a light bulb on the other end of the sheet leaving the center of the paper blank. Once the coal and bulb were drawn, youth were asked to illustrate how coal eventually lights up a bulb by filling in the intermediate steps of the energy transformation process. Once the youth finished filling in the parts, they were asked to circle places on their illustration where possible harm to the environment can occur. Follow up questions were used to elicit details from the youth and what they know about energy efficiency and the energy transformation process.

The interview lasted approximately one hour. The interview was transcribed and coded for examples of youth ideas around science content and place-based storylines. I wanted to know if the storylines persisted after completing the unit and whether there were any changes in content knowledge or the message they had for others to know. Furthermore, I noticed how youth conducted themselves as interviewers during the interview forcing us to re-analyze the interview to ask whether youth interaction also contained counterstories.

I acknowledge the potential biases when I apply certain analytic tools and theories to the data. In order to minimize these biases, the analysis was presented multiple times to the research team for feedback and discussion. These presentations and conversations served as a form of member checking as I worked with the data. The interview also served to verify specific parts during the analysis of the video including science content knowledge of the youth.

The Light Bulb Audit video[1]

The Light Bulb Audit video started with a series of images while the lyrics of the song stated, “waiting on the world to change”. The first image showed youth appearing playful as the text “Pleasant View Magnet School” appeared. Two additional images follow of an incandescent light bulb then a CFL bulb accompanied by the text, “MAKE A CHANGE”. The video transitioned to the youth in front of their school explaining what they were about to do as they ask the audience whether they think the school is being green.

Then, the video transitioned to the youth engaged in a light bulb audit of each bathroom in the school to see how many CFLs they can find over the less energy efficient incandescent light bulbs. Bathrooms are located within each classroom at the school. In between inspections of each bathroom, the youth infuse information about the number of watts used by incandescent light bulbs versus CFLs and good-naturedly chastise their teachers for not being green. They discovered that all but one bathroom had incandescent bulbs helping set up their content storyline around their explanation of how using incandescent lights requires more coal to be burned leaving to environmental consequences of human action on climate change.

The youth explained how they were able to determine incandescent lights were less energy efficient by the heat they release and elaborate on how this has an effect on the environment. They situate the issue locally by reminding viewers that the city receives its electricity from burning coal. The LBA video brought in pictures of a strip mine as the song lyrics ask, “What have we done to the Earth?” The video alternates between the youth on camera continuing to tell the story of human impact on the Earth and images with text explaining

[1] The Light Bulb Audit video can be viewed at: http://streaming.msu.edu/storemedia/download/acb/GETCity/YEAR_4/Pleasant-View-Light-Bulb-5.mov

how damage done from mining is not reversible. The youth then pulled in the problem of excess CO_2 being produced from the burning of coal as energy consumption goes up.

In a sequence connecting across several parts of the content storyline, the youth move from the burning of coal to the use of light bulbs to greenhouse gases and climate change. The video starts with one of the youth narrating before transitioning to an image of a yellow warning sign with the large letters "CO_2" and smaller text "Climate Change" within the "O" and followed by an image of the Earth on fire in the palm of a hand.

Table 1

Visual and Narration Example from the Light Bulb Audit Multimodal Video

Visual	Narration
Video: Chloe talking Video: Yellow warning sign with CO_2 (Climate change written in the O) Video: Image of globe on fire in the palm of a hand	Chloe: Not only do they give us pollution but they also release carbon dioxide. Ayana: You know CO_2. Chloe: The problem with greenhouse gases, like CO_2, is that they contribute to climate change.

The video placed the onus on human actions but also offers a chance to the audience to remediate habits and be empowered to make a change. The next portion of the video uses images and text instructing the audience that they can make a change and that as the song suggested, "it's easy as 1, 2, 3…A, B, C".

In order to make their appeal, one of the youth appears on camera to explain the amount of money the school can save as well as how much CO_2 release can be prevented by switching light bulbs. The video closes with the scrolling text reviewing how incandescent light bulbs used more energy requiring more coal burning and CO_2 release that leads to global warming as the song played "I'm asking you to make a change".

Analyzing the Light Bulb Audit

Halvorsen (2010) described her work with a group of youth trained in movie making techniques. The youth produced a video about themselves that were analyzed as a way to explore what the videos revealed about youth identity. She outlined the process of cataloguing elements of a multimodal video in order to uncover ways in which youth identities were represented. While my work is not on identity, I drew from Halvorsen (2010) to develop a modified approach to analyze the moves youth made when purposefully selecting multimodal elements and both the explicit and implicit messages that were delivered.

The analysis of the LBA video started with isolation of the components of the video through the process of cataloguing. The video artifact was transcribed and the separate components identified and organized into a data table (see Appendix A). The components included: (1) Narration and spoken word; (2) text including word choice; (3) visual components; (4) music and sound. I identified the units for analysis as discrete video clips bounded by transitional elements. Time stamps were given where distinct transitions occurred in the video. The clips represented distinct parts within the larger storylines. For example, a transition might have included a shift from a message on energy efficiency to a message about human impact on the environment through use of the different elements.

A key part of the unit of analysis was the way in which the various elements that were used to construct the clip interacted and contributed to the storyline. According to Halvorsen (2010), the elements collectively tell a story and thus need to be analyzed as a whole. I isolated

each component to insure I captured all of the elements youth included in their video and how they contribute to the larger story.

Furthermore, a secondary analysis required expanding the unit of analysis to include the video and context. The context of for whom the video was intended as well as the purpose behind the creation of the video add an important layer to understanding the development of the LBA. The context enables me to make claims in the findings section that would otherwise bear little merit without understanding why the youth created the video.

I return to the vignette from the start of this paper to provide one explicit example describing how the process of analysis was applied to the video artifact.

> Michael Jacksons *Earth Song* is heard as a video clip from a student made public service announcement plays. The song lyrics ask, "What have we done? Look what we've done". An image of a large mine appears with text declaring, "This coal mine used to be filled with trees and grass."

The youth were adamant about using this particular song in their video for the way they envisioned the music helping to tell their story and Michael Jackson's death had repopularized his music. The lyrics matched with the powerful image of a strip mine speak to the audience about the damage caused to the environment. I attempted to recognize the intentionality of the chosen elements of song, pictures and text and how these individual elements were woven together to form a message the youth wanted to convey.

In this short segment, each of the multimodal elements had a role in the overall story. Youth revealed knowledge of the destruction of landscapes due to burning coal at the local power plant in the images selected. The youth connected to the audience through the music. In particular the lyrics referring to "we" implicate the members of the community role in what is happening to the environment. Together, the elements told the story of the environmental consequence through stark images, emotionally charged song lyrics, and purposefully select text.

Analyzing the Interview

The initial coding looked for specific instances where youth exhibited content knowledge due to the mapping activity used with the interview. The goal was to identify the depth of knowledge youth provided to support my claims around the science presented in their PSA. Furthermore, as an informal science learning program, I wanted to know what the youth did in fact learn through their participation. I also wanted to know whether youth could move between system level knowledge to more discreet knowledge of energy transformation and energy efficiency. That is, could the youth describe an overview of how switching to a CFL light bulb can impact climate change. Or, at a much finer grain size, could the youth describe how energy stored in coal is used to generate electricity.

Counterstory in the Video and Interview

Counterstory requires that there be an object to which something is diametrically opposed. While the analysis revealed many potential counterstories, we focus on the counterstory that emerged through community. That is, the dominant narrative around the community to which the youth belong suggests that they are less likely to engage scientific issues, partake in the practices of science, and carry out transformative actions.

Angela Calabrese Bart..., 12/6/11 9:26 AM
Comment: I think this needs more clarity. Im not sure what you mean by community??

During the secondary analysis, powerful examples of counterstories being told by the youth emerged against the backdrop of the context in which the video was created. In other words, the initial purpose for the creation of the video left open the possibility for counterstories

to be told. Knowing the intended audience provided a background for examining how and why the messages within the LBA were constructed in particular ways. I delved further specifically seeking to explore the counterstories of how youth challenged to existing power structures, the anti-hegemonic positioning of youth of color, and critical agency taken by the youth. I coded examples that captured youth understanding of science in relation to their horizontal knowledge in transformative ways. I defined transformative examples by identifying places where youth were able to use scientific knowledge and communicate with their audience in non-traditional ways. I looked for examples where youth demonstrated power by taking ownership of the science knowledge and how they positioned themselves in relation to the audience. Finally, I documented how youth became doers by using both scientific and horizontal knowledge to engage the audience in becoming agents for change. I will nuance these examples in the findings section.

Findings

I wanted to understand how and why youth took up and represented scientific ideas in their videos with their intended audience in mind. In this section, I present the analysis in three phases. First, I use analytic descriptions of the themes that emerged. I describe both what youth communicated they knew and how they "packaged" what they knew to build a compelling science storyline to a particular audience in locally meaningful and culturally relevant ways. The data revealed that youth draw from a strong scientific knowledge base to inform their video while connecting to their community and making science accessible. The youth also use the video as a means to position themselves and others to actively pursue change to improve their own community through science. In particular, I discuss how the youth used the video artifact to engage their communities in science by: (1) situating science in the community; (2) making science accessible; and (3) positioning themselves and others as knowers and doers of science, as a way to understand the significance of what is revealed by youth in terms of who can do science and what it means to be scientifically literate.

Second, I offer a descriptive analysis of the relationship between the three themes and expansive learning along vertical and horizontal dimensions. That is, how does expansive learning help us understand the three themes from the first phase? The analysis looked at whether youth pull from vertical and/or horizontal learning dimensions in the construction of the video. I find it necessary to consider whether knowledge that draws on only one dimension is sufficient to tell a compelling story through video or if it is necessary for youth to negotiate both the vertical and horizontal dimensions to craft their message.

Finally, I considered how counterstories are found in each of the three themes. Specifically, the most prominent counterstory was how the youth engaged the community and the one this paper will focus on. Exploring this particular counterstory through the three themes illustrated how the video challenged the dominant narratives told about the community of the youth and others communities like their own engage with science. I expand on this idea of community and science within each of the themes that follow.

Situating science in community

For the youth, I argue that situating science in community is at the core of their participation in science and desire to spread the message with those around them. The youth connect to the physical community, the individuals that make up the community, and draw upon their own deeply rooted, personal connection to community. Likewise, they also recognize that there is a larger world beyond their own familiar surroundings as they think globally about the ramifications of wasteful energy practices.

Angela Calabrese Bart..., 12/6/11 9:29 AM
Comment: OK, I like very much how you set up this direction and your choices here make sense. I think you can work on the wording so that these two paragraphs area clearer. They are a bit hard to navigate right now.

Angela Calabrese Bart..., 12/6/11 9:30 AM
Comment: What message. Be explicit.

Angela Calabrese Bart..., 12/6/11 9:30 AM
Comment: I like these two previous sentences.

The youth use local points of reference as a means to leverage the science with their audience. If we return to the vignette from the LBA video at the beginning of this paper, the youth explicitly pinned their environmental message in the local area by calling out the nearby power plant and it's smoke stacks visible from their own homes or along the commute in and out of the neighborhood. The youth selected a striking image with billowing smoke to make the connection rather than explaining within the video clip the impact of smoke and CO_2 on the local environment (Figure 1). The music fades and Chloe asks the viewer, "Have you ever seen those smoke stacks?" The youth complete the bridge from the smoke stacks to the science by explaining:

> Chloe: Not only do they give us pollution but they also release carbon dioxide.
> Ayana: You know CO_2.
> Chloe: The problem with greenhouse gases, like CO_2, is that they contribute to climate change.

In another example, the youth situated the issue locally by reminding viewers that the electricity for the city comes from burning coal. They explained how they were able to determine incandescent lights were less energy efficient by the heat they release and elaborated on how this has an effect on the environment. The LBA video brought in pictures of a strip mine as the song lyrics ask, "What have we done to the Earth?" The video alternated between the youth on camera continuing to tell the story of human impact on the Earth and images with text explaining how damage done from mining is not reversible. The youth then pulled in the problem of excess CO_2 being produced from the burning of coal as energy consumption goes up. In this way, the youth allowed the image to drive home the message that our reliance on coal powered energy has a detrimental effect on their community. There was a dual outcome from the way the youth orchestrated the clip. They explicitly named the local space but also situated the problem of burning coal locally for audience members.

Figure 1. Screen capture images from the Light Bulb Audit video. The local power plant (left) and image of smoke stacks (right).

Situating was also a useful way for youth to problematize issues closer to their immediate sphere in order to elevate the centrality of the science. As youth, much of their time is spent at the local school so they used the issue of looming budget cuts and the implications on their school experience to argue for changing energy usage patterns and behaviors. The girls often expressed concern to research team members about losing various programs if the school did not have enough money. In response, the youth conducted the light bulb audit at their school, a shared physical space within the community, to provide a scientific rationale for making a

change. They illustrated how using CFLs can impact the larger system of energy production and climate change. The story came around full circle back to the school as the youth presented the estimated financial savings and pounds of CO_2 prevented from being released if CFLs are used in all of the bathrooms in the building. The youth argued by making a change to CFL bulbs, we in turn help the school save money but also join in the battle against climate change (Figure 2).

Figure 2. Screen capture images from the Light Bulb Audit video. The estimate savings on utility bills for the school (left) and the estimate pounds of CO_2 prevented from release into the atmosphere (right) if incandescent light bulbs are replaced with compact fluorescent light bulbs throughout the building.

In a third example, situating the environmental concern as a local issue allowed youth to make explicit the roles the local community members have played and new roles they can adopt in the fight against climate change. The youth targeted individuals in the community by suggesting the choice to use inefficient light bulbs wasted energy and had a detrimental impact on the environment. They begin to develop the story of how the personal choices have consequences and go on to show how mining for coal and the release of greenhouse gases from burning coal are problematic. The youth provide evidence from their experience having conducted a comparative experiment between the two types of light bulbs and discovering how the heat released is one way to determine energy efficiency (Figure 3). The emphasis on the relationship between the use of electrical energy and the loss to heat from a light bulb required the youth to understand energy transformations at the system levels (coal to electricity) and on a smaller scale (electricity to heat/light). But more importantly, the youth worked to connect science with individuals in the community.

Figure 3. The youth participants explain the light bulb experiment during the interview.

In response to one of the interview questions, the youth continued to push on the role of others to situate the concern globally. The question asked what happens to the steps in their illustrations of the energy transformation from coal to electricity if more people made the switch to using the more energy efficient CFL bulbs. In the response given below, the discussion suggested youth have ability to coherently work through the content storyline backwards and recognized how the onus is on the individuals of the community to lead local efforts in the "Change a Light, Change Michigan" campaign. While recognizing that the term *everybody* is very broad, I argue that the all-encompassing word speaks to both the local community but perhaps also drives toward a more global vision. The following exchange highlighted youth connecting the use of CFLs to reduction in coal used and the positive outcomes for the environment:

Interviewer: Okay, what happens to the other parts so, what happens to the coal? Let's say that everybody decided to use CFL's-
Chloe: This coal would be smaller. This whole pile would be much smaller, so like that would be cut off. (marks on paper)
Interviewer: So it would be a smaller pile of coal? Why?
Chloe: Because it's burning less coal *if everybody* changes to CFL's we're burning less coal so we'll need less coal.
Ayana: There will be less coal. Like, the pile won't be as tall it will be small.
Chloe: So how about we'll need half of what
Jocelyn: We wont need as much coal as we need now for the incandescent.
Chloe: Or if, in the future we could get rid of coal that would be great too.

A few lines later in the interview, Jocelyn reiterated the connection between changes in energy use behavior across communities can have an important environmental benefit:

Jocelyn: I think a lot more pollution and CO_2 would be reduced as well if *everybody* switched to CFLs. Because the CFLs make pollution but they don't make as much pollution as incandescents.

As seen here in the interview, the concerns of the youth reached beyond local activity and connected to the bigger systemic picture. By including the images of the power plant as a launching point, the story is about how local decisions are intertwined with global concerns. The youth used their system level scientific understanding of energy efficiency and energy production and connected authored a message for the individual community member to be able to take agency.

By situating the science in the community, the youth drew heavily upon the vertical dimension of learning. The focus on science meant youth needed to use their knowledge of the problem associated with energy efficiency and coal dependence before they could share with the audience. The horizontal dimension was also necessary as it allowed youth to use physical landmarks (power plant and school) or the people that live in the area helped make the message relevant for the audience. Furthermore, horizontal knowledge allowed youth to take the content knowledge acquired through their experiences and present them to a different audience. Herein lies the transformative power of the way youth negotiate the horizontal dimension as active participants in multiple communities around science issues.

The digital video became the means through which the youth moviemakers employed counterstory by sharing scientifically supported concerns with other members of the community. African-American youth are often unfairly portrayed as disconnected from science as well the communities the come from perhaps in part to low standardized science test scores. Yet, the video refutes the idea that youth of color do not share in science-based concerns and problematize climate change for their local audience. The video appealed to the common investment in the well-being of the spaces frequented within the community with hopes that the science concerns would resonate and call members to action.

Making science accessible

The youth recognize that in order to reach their audience they must appeal to their concerns and interests to make their message accessible. I use the word accessible to mean presenting science in a way that is meaningful to multiple, different audiences and free of the technical language that is often a barrier for those outside of the scientific community. In other words, they youth repackage and re-present science using a language easily understood by their peer audience without losing scientific integrity. The intended audience was integral to how the youth storyboarded the video and presented their messages. The youth also took advantage of their membership within the peer group that comprised the audience to know what did have appeal. Recognizing that science is not necessarily easily understood in technical terms or may not be a primary concern of the intended audience, the youth made choices in the assembly of their video that granted access to science and arguably hooked the audience in while staying true to the complex environmental concerns stemming from to energy use.

The way youth communicated their message challenges the idea that the language of science must be explicit in order to convey and understand phenomenon. There is a great deal of savvy in the composition of the video because it accomplishes two things: (1) communicates science in a way that broader audiences can attain; (2) challenges the notion science must be communicated in narrowly construed ways. In order to achieve these goals, the youth employed three tactics that infused the LBA with catchy pop music, powerful imagery, and their playful personalities in the finished production. I describe each of the three strategies below and use examples of how the youth made the science accessible through their video.

Within the multimodal video, the choice of music carries an important role for both the youth and their message. The youth borrowed music from superstars John Mayer, Michael Jackson and the Jackson 5 and capitalize on the lyrics that speak to their environmental concerns and to the audience. At the time, John Mayer's song was a hit and Michael Jackson was in the midst of a resurgence in popularity due to his untimely death. John Mayer crooned, "We keep on waiting, waiting on the world to change". Michael Jackson chimed in stating, "if you wanna make the world a better place, take a look at yourself and make a change" while the Jackson 5 reminded viewers that making a change is as "easy as one, two, three". The repeated theme of change across the songs reminded viewers of that the point was more than just to watch the video but rather to go out and actively make a difference. On one hand, we could "keep on waiting", or instead take responsibility by looking in a mirror to recognize our own culpability, accept the challenge being issued, and make a commitment to change. The youth, in fact, wanted audience members to sign a pledge after viewing the video to change their energy usage habits and save more energy.

While some imagery has been highlight earlier such as the use of the smoke stacks from the power plant, other images and graphics further work toward making science accessible. The youth borrow stock photos and strategically place them in the video. For example, they used an image of a yellow warning sign with the abbreviation for carbon dioxide, CO_2. Within the "O", the words "climate change" can be seen driving home that viewers are warned excess CO_2 can lead to climate change. The next image was of a small globe representing the Earth resting in the palm of a pair of hands. The globe is on fire. The selected image reiterates the Earth will "burn up" due to climate change if we, as indicated by the hands, do not change our ways. The narration provided by the youth reminds viewers of the role of CO_2 and science to explain climate change.

Chloe: Not only do they give us pollution but they also release carbon dioxide.

Ayana: You know, CO_2.

Chloe: The problem with greenhouse gases, like CO_2, is that they contribute to climate change.

Figure 4. Screen capture images from the Light Bulb Audit video. Warning sign (left) and globe burning in the palm of a hand (right).

In another peer attention capturing and accessibility move, Jocelyn playfully chastises her teachers that had incandescent light bulbs in their classroom bathrooms during the audit saying, "I'm disappointed in you". While having fun at the expense of the teachers, the video also raises the issue of waste energy from using inefficient light bulbs and how energy can be conserved.

Chloe: We discovered that not all the bathrooms were hogging energy. Some actually had CFLs. (Screams of joy)
Jocelyn: Oh my gosh it's a CFL! That's Ms. Stanton. Go Ms. Stanton! She is efficient, baby! Get it right!
Chloe: But the bulb wasn't hot. That's how we knew it was a CFL.
Jocelyn: Because incandescents get hot because they create more heat than CFLs and CFLs are efficient.
Jocelyn: Good job for…
Ayana: Go girl!
Jocelyn: ….for getting a CFL in your bathroom. It makes a difference and it saves energy.

Rather than didactically delivering science content, the youth used their own creativity to have fun with the audit and their teachers and generated widespread appeal for the video and science message among their target audience members.

Figure 5. Jocelyn playfully reprimands a teacher for not using compact fluorescent light bulbs. In this scene, Jocelyn is waving her finger back and forth with disapproval.

In this sense, the youth transformed scientific knowledge in ways that are accessible to different audiences by drawing on the horizontal dimension. This is counter to the assumption that in order for an individual to master science, they must also adopt the language, depth, and understanding of scientists. Rather, the youth used knowledge of the audience to inform their moves as moviemakers taking the same message and being able to communicate effectively across difference groups.

Positioning as knowers and doers

The youth were positioned as knowers and doers of science both in the process of making the video and within the video. Embedded in the idea of being knowers and doers is that youth also found themselves in new positions of power. The participants located themselves as

authoritative and knowledgeable figures in relation to conventional persons in those positions such as teachers and science experts revealing a shift in power dynamics. Furthermore, the video extends the power to the audience imploring viewers to position themselves as doers and make a change. The audience is empowered not only by the urging of the video, but also the transfer of scientific knowledge of the ways energy inefficiency has a negative impact on the community.

The video presented the youth as actively able to apply their science knowledge in ways that engage peers in making a difference in the community. By choosing to appear in the video, the participants became the focal figures in the gaze of the audience. They were positioned as science experts before their peers in a role not often reserved for youth of color. For the peer audience members, they witnessed knowledgeable youth engaged in using science to evoke change in the community. Furthermore, the audience was also empowered both by seeing peers as leaders for change and being charged to join the effort since it's "easy as 1, 2, 3".

Throughout the LBA video, the youth are positioned as both knowledgeable and doers of science. For example, the video started with a series of images while the lyrics of the John Mayer song stated, "waiting on the world to change". The first image showed a picture of non-participant youth perhaps dancing in a physical education class as the text "Pleasant View Magnet School" appeared on the screen. Two additional images follow of an incandescent light bulb then a CFL bulb accompanied by the text, "MAKE A CHANGE". Immediately, the video reached out to the audience by using the school name and connecting locally. The image of other youth provided the audience with the sense of "other kids like me". In the first few seconds, the video had already informed the audience they were connected to the story about to be told through their school and that they were positioned as the target audience. The video transitioned to the youth video authors in front of their school giving introductions and explaining what they were about to do as they ask the audience whether they think their school is being green.

Figure 6. The three youth authors of the Light Bulb Audit stand in front of their school to introduce their investigation of the school to see whether energy efficient light bulbs are being used.

The youth moviemakers also took on a position of power in relation to the teachers and administrators of the school building where the light bulb audit took place. The youth elevated their position in relation to the school authority figures by leveraging their knowledge of energy efficiency and the impact of burning coal to generate electricity. The knowledge allowed the youth to remind their teachers that the incandescent light bulbs found in their rooms are wasteful of energy and detrimental to the environment. The youth are not being defiant of authority, but rather demonstrating that they are quite vested in the concerns of the community and empowered to be leaders for change. They found agency through science to engage the community and school leaders to consider ways toward a better future.

Furthermore, I push on the position of teachers in relation to the audience as set up by the video makers to argue that this clever move extends power to their peers. Not only did the youth appearing in the video enjoy their higher status, but now the peer audience was more knowledgeable after learning the message of the video. The peer audience was positioned to have knowledge that their own teachers couldn't demonstrate. In fairness to the teachers, it isn't necessarily that they didn't know or that they were even responsible for installing the bulbs in their rooms, but rather that the audience was positioned as knowers in preparation to become doers as seen in subsequent parts of the video.

After explaining the environmental impact of burning coal for electricity compounded by not using energy efficient light bulbs, the audience was positioned as doers. The LBA urged viewers to change their behavior by replacing less efficient light bulbs. The text in the video states, "Because you can help!" and to "Just change a LIGHTBULB!" followed up with the slogan "get out with the old and in with the new!" The text appears over images of various light bulbs including CFLs while the Jackson 5 song plays reminding the audience, "it's easy as 1, 2, 3". Armed with scientifically supported knowledge, the audience could now do their part to take on the environmental issues.

As the participants shared their message with more audiences, they embraced their position and role to become leaders in the efforts to encourage others use more energy efficient practices. I saw this transformation when I asked the youth to explain the experimental set up comparing incandescent and CFL bulbs. Rather than launching into an explanation, the three youth switched the role from interviewees to interviewers. Or more accurately, the three youth assumed the role of expert as they launched into questions of me asking for predictions and interrogating my knowledge of the two light bulbs.

Chloe:	All right. So this one's [incandescent] on and this one's working [CFL].
Ayana:	(Directed to the interviewer) What do you think that one [incandescent] and this one [CFL] is going to be?
Chloe:	(Directed to the interviewer) What do you think the incandescent is going to be and what do you think, measuring temperature, the CFL is going to be?
Interviewer:	Okay, so you're asking me now?
Unison:	Yeah.
Interviewer:	Well what if I don't know? I have no idea. I'm clueless about this kind of stuff.
Chloe:	Well we're going to tell you.

The seemingly innocuous switch in roles is significant if the shift is understood as a counterstory. Typically, the adult is often the interview and the youth are interviewees in education research. In this case, the youth were empowered to use both the scientific knowledge

gained through participation in the program and their knowledge of the community. The three leveraged their knowledge against my knowledge as an outsider as they assumed the role of experts. Since I was asking about the experiment, the trio assumed I was not well informed rather than viewing me as a potential assessor of their scientific knowledge. Their action and my approach to the interview were very deliberate. The interview questions were set up as conversational versus evaluative in nature opening to the possibility of a flow of ideas and discussion.

But why is this role switch important to recognize. Beyond positioning themselves as experts, their action is a counterstory against hegemonic ideas of who can do science, who holds scientific knowledge, and how scientific literacy is defined. Youth are not frequently seen as scientists or experts and even more so among populations of color, but in this example, youth use science to explain energy efficiency.

The horizontal dimension of learning surfaced throughout when thinking about positioning. For example, horizontal knowledge enabled youth to position the audience to both receiving content knowledge but also position viewers to make a change. The scientific message was mediated by their horizontal knowledge in order to provide the audience with the knowledge to justify making that change and in turn become change agents themselves. The youth video authors are also positioned as change agents as science experts as they show their light bulb audit and argue for the estimated savings. All of these moves are predicated upon the horizontal dimension, as it is necessary for youth to be able to work and communicate across populations.

The effective positioning of themselves and their audience as changes agents serves again as a counterstory to popular notions of who can do science. The youth actively position themselves as more than participants in science by assuming the role of experts. Youth of color are typically not received as experts in science but the video makes a statement to the contrary. Furthermore, populations of color are often marginalized as potential participants in science but we see the youth provide a way for community members to join the counterstory by making change.

Situating science in the community, making science accessible, and positioning as knowers and doers of science served as the foundations for youth participation in GET City, the making of the LBA, and presentation to different audiences. The motivation to make the video was deeply embedded in the youths' personal sense of community. The youth were concerned about the wellness of their own community and the long-term stability of their school. The school saving money meant that perhaps it would retain various programs that faced elimination in the era of school budget cuts. It was not surprising to see youth concern centered on the benefits toward their school where they have spent so much of their early lives and that is a vital component of the community. The multimodal nature of the video along with the creativity and playfulness of the youth made the video accessible and added to the attraction of the audience toward the video. And with a captive audience, the movie reinforces the scientific knowledge while urging peers to make a change.

Discussion

The youth in this investigation used their multimodal digital video to engage their peers and the broader community in a discourse around environmental issues. By situating the concern around local and real issues backed with scientific evidence, the youth wanted to draw the interest of the community. In order to ask the audience to partake in caring for the places and spaces in their world, the youth had to devise strategies, as seen in the LBA and described in the findings section, which piqued the concern of audience members. To this end, the youth

embraced the possibilities presented by digital video making and developed a PSA specially designed for a community audience.

It is important to recognize the role of counterstory in the creation of the multimodal video artifact. Not only was the video a counterstory for the three youth who created the video, but also a counterstory for the viewing audience. The video invited the audience to share in the concerns of the community and called for action extending for whom this counterstory served. The youth participants and their peers come from communities that are traditionally underrepresented in science leading to the notion that these communities are disconnected or disinterested without fully considering that the science discourse might be inaccessible and dissimilar from the discourses they regularly engage. Youth of color are also victimized by assumptions placed upon them as less capable of knowing and doing science if achievement gap data and reports continue to focus on the disparity rather than the gains made over time. In light of these hegemonic ideas, youth counterstories emerged from their authoring of the digital artifact as a powerful way to understand their participation.

By engaging in the telling of counterstories, the youth enable their community to speak back from a marginalized position and challenge the identities given by those who have traditionally held ownership especially over scientific knowledge. For example, the youth were aware of the budget cuts facing their school and schools throughout the district. Much of the talk centered on programs that would be cut, reduction in services and staff, but not around ways money could be saved. This pushed the youth to think about how energy saving practices around their school could help make a difference in a tough economic climate. The PSA was grounded by intimate knowledge of local concerns that also served as a springboard for youth to bolster their argument with scientific argumentation. The light bulb audit and the scientific investigation of light bulb efficiency provided the youth with supporting evidence and a more convincing argument that choice matters. For the youth to take knowledge and author a video such as the LBA serves as a strong counterstory to the notion that youth of color underperform in science especially when youth are observed striving for transformative ways to help the community.

The counterstories documented raises questions about the role of expansive learning especially the horizontal dimension. I argue that the way the vertical and horizontal dimensions of learning become interwoven deserves to be explored and better understood as a means to rethink science learning. While most would agree that sufficient content knowledge is necessary to understand science, the horizontal dimension must also be legitimized as an important and necessary component in science learning. The horizontal dimension affords space to consider the cultural intricacies of different populations of learners that challenge dominant narratives of who can and does participate in science. It is from the horizontal dimension that counterstories are revealed.

By looking at the two dimensions of expansive learning, one sees that the intersection of horizontal and vertical knowledge is dynamic and complex. What I mean is it that simply mastering science knowledge is not sufficient to participate in science but rather youth carefully leverage both dimensions and repackage their message allowing them to move across audiences. The youth were immersed in technical scientific knowledge through their investigations and opportunities to meet with scientists that they transform and effectively communicate scientific ideas across various communities pushing for action toward justice. For example, science is re-presented in an accessible format that enables youth to not only expound on the economic sensibilities but also deliver an important subtext concerning the health of the environment in which we all share and live. The youth raised environmental quality and climate change as an

issue since their community lies in the shadows of the smoke stacks from the nearby power plant. The video offered viewers a means to take action by starting with the simple measure of changing to more energy efficient light bulbs as a cost effective measure and a step forward in the fight against climate change. All the while, the youth exhibit a deep understanding of the science to support their rallying call to peers to take action.

In this investigation, the youth became self-appointed leaders in the 'make a change' effort. Their action directly counters the narrative that suggests youth of color do not value science and consistently underperform in science. In fact, the youth in this investigation not only performed at high level when doing and explaining the science, but they applied science to real life issues that led to change. Final form science learning rarely asks students to apply science concepts to solve problems. The core of what it means for marginalized populations to be scientifically engaged is captured in the ways the youth worked to transform the conditions in their community by drawing from their vertical and horizontal knowledge and actively participating in science.

Conclusion

The counterstories of the youth participants push us to reevaluate and consider how youth engagement with science is deeply connected their lived worlds. A linear understanding of science learning fails to capture how science is taken up by the youth and used to make sense in their context. Rather, the horizontal dimension allowed youth to draw upon the economic strife in the community and their desire to make a change to orchestrate a compelling scientifically based argument for fighting climate change. Horizontal knowledge drives the youths' scientific investigations and informs that way they tell their counterstory.

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