Integrating Engineering into an Urban Science Classroom

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ABSTRACT: This article presents a single case study of an experienced physical science teacher (Janet) integrating engineering practices into her urban science classroom over a two year time frame. The article traces how Janet's understanding of the role engineering in her teaching expanded beyond engineering as an application of science and mathematics to engineering as a humanistic and socially-just activity with the potential to empower her students. The data for this qualitative case were gathered over a two year period during which the teacher participated in an engineering professional development program. The data were gathered from five interviews, observations of implementation, student artifacts, lesson plans, and Janet's journal reflections. Three primary themes arose around the role of engineering in her urban classroom: real-world problems and applications, student engagement and learning, and solving complex problems. These themes each contributed to Janet's expanded understanding of engineering from a focus on engineering as a general STEM career to engineering as problem solving strategies which empowers students to be active participants in their urban community.

Keywords: urban science teaching, engineering practices, secondary science, social justice

Research demonstrates a persistent education deficit (Ladson-Billings 2006) between urban and/or low SES science students and their more affluent suburban counterparts (Barton & Tobin, 2001; Knapp & Plecki, 2001; Fraser-Abder, Atwater, & Lee, 2006; Cone, 2014). Although science education research has made strides towards understanding what effective science teaching looks like (Knapp & Plecki, 2001), the implementation of these practices into classrooms, urban and otherwise, has proven difficult (Fraser-Abder, Atwater, & Lee, 2006). Standards-based instruction with its analogous testing continues to highlight difficulties closing this science achievement gap (Geier, Blumenfeld, Marx, Krajcik, Fishman, Soloway & Clay-Chambers, 2008). It is unclear how the adoption of the *Next Generation Science Standards (NGSS)* by many states will impact this urban/suburban science achievement gap. However, we do know the new standards require urban science teachers to add engineering practices into their science instruction.

The addition of engineering practices has left science teachers across the nation struggling with how best to implement this new and complex reform goal, a situation potentially more complicated for urban science educators. Urban secondary science teachers are frequently faced with greater accountability pressures, less prepared students, rigid curricula, and low expectations for student success than their suburban counterparts (Barton, 2001). Additionally, there are few examples of what effective integration of engineering looks like that would provide guidance to the courageous teachers who are willing to take on the challenge.

In this qualitative case study, I present Janet's two year journey as a participant in an engineering professional development program. The case explores how Janet's view of the role of engineering in her instruction changed over her two years of participation in the professional development program. Janet's story was documented through interviews, observations, and surveys to understand her beliefs about teaching with engineering at program entry and after two years of implementation. Janet's reflections on her and her students' successes and struggles with the engineering integrated instruction provide insights for other urban science teachers on the potential of integrating engineering practices into urban classrooms. Specifically, I focus on the following research question: In what ways does an experienced urban educator's beliefs about teaching with engineering change over cycles of implementation to meet the needs of her urban students?

Review of Literature

This study is situated in two literature bases: urban science education and the engineering education. The urban science education literature establishes the call for change in how we are working with urban youth in science classrooms and the reform-based instruction suggested to close the current education debt. The engineering education literature adds detail to this specific science reform-based strategy as suggested in the new national standards. This literature provides a powerful argument for the inclusion of engineering into the science curriculum. This study brings these two literature bases together by detailing how one urban science teacher brought engineering education to life in her classroom and by doing so found ways to overcome aspects of the urban education debt.

Urban Science Education

If we rely singularly on the statistics about the success of urban students' science achievement, the situation is bleak. Martin, Mullis & Foy (as cited in Cone, 2014) found that students in urban schools, nationally and internationally, were well below the international average on the 2007 Third International Mathematics and Science Study (TIMSS). In addition U.S. national reports indicate a significant achievement gap between the students of color, who are likely to populate urban schools, and their white counterparts (National Center for Educational Statistics [NCES], 2011). This same report disaggregated the data further to isolate out students living in poverty and found low income students performed well below their more affluent peers.

Reasons for the reported lack of success, education debt (Ladson-Billings, 2006) for urban secondary students in the sciences parallels that of other academic subjects: ". . . curricula designed for low ability students, limited access to the best qualified science teachers, preconceived stereotypes about diverse student groups which affect teacher expectations and an educational system that is structured to benefit the hegemony" (Cone, 2014, p. 161). In addition to these systemic challenges, urban science teachers frequently face limited resources, including laboratory materials as well as instructional time, a lack of classroom authority to make decisions about deviating from tested accountability measures, and students who themselves have internalized a dislike for science and learning (Barton & Tobin, 2001; Fraser-Abder, Atwater, & Lee, 2006).

In *Science Education for All,* researchers and policymakers repeatedly called for the use of reformed-based instructional models that are based on a socio-constructivist learning framework and draw upon students' experiences and topics of relevance (Barton, 2001; Elmesky & Tobin, 2005; Geier, et. al., 2007; Cone, 2014). The reform-based models sought to counter the dominant curricular trends found in many urban science classrooms by engaging the students in complex science investigations, such as true laboratory research, problem-based learning, student driven inquiries, or a focus on socio-scientific issues. These instructional models have shown promise within their individual contexts, but barriers to expansion remain. However, if the science achievement gap is to be closed, success on the small scale must continue be supported while new innovations are developed, implemented, and researched offering urban science teachers a full array of reformed-based models of instruction.

Engineering Education

The *NGSS* framework requires the explicit inclusion of the engineering design process (EDP) as both a process for learning core science concepts and as a context for instruction (Achieve, Inc., 2013). The use of engineering in science education is not new; students have had egg drop challenges and built catapults for years. In its early use the engineering design process was viewed as a gateway to authentic learning (Crismond, 2001; Kolodner, 2002).

However, the *NGSS* clarified the role of engineering and determined it to be an essential aspect of the study of science on equal footing with science inquiry. Rodger Bybee (2011), in preparation for the forthcoming *A Framework for K-12 Science Education* (National Research Council, 2012), elaborated and exemplified the comparable practices used in inquiry and engineering. The NRC's *Framework* (2012) did not define a specific engineering process, rather developed broad outlines for the design process that engage students in all eight practices.

With the establishment of the *NGSS,* there was a general agreement that engineering-based instruction engages students in grappling with the underlying science and mathematics content in a design problem. However, engineering does not exclusively rely on science and mathematics (Hynes and Swenson, 2013). Engineering is a human activity, one which seeks to overcome problems of humans. Hynes and Swenson (2013) see an additional goal of engineering in K-12 classrooms to introduce the social science and humanities into science instruction. They propose that engineering should be understood as a holistic pursuit where "social sciences and humanities knowledge and skills are applied in the pursuit of engineering *for* people as one engineers *with* people" (Hynes and Swenson, 2013, p. 32). A humanistic engineering focus requires an understanding of the constraints on design as determined by the needs of people and societies that are frequently shifting, contentious, and require judgment calls and empathetic decisions. In addition to disciplinary science and mathematics, Hynes and Swenson's (2013) vision of engineering *for* and *with* people in classrooms engages students in following disciplines: psychology, sociology, communications, law, economics, and ethics. Including this human focus on engineering, teachers and students must grapple with a broader range of problems, issues, and constraints that can give rise to discussions of power, voice, and justice.

Penuel (2014) directly argued for the importance of science and engineering being taught as practices in order to fully engage a humanistic view of engineering. He framed the need to shift to a humanistic view because "focusing on science *in* practice, …, foregrounds peoples' contributions to everyday social practices and asks how science and engineering figure in and are developed through social practices" (p. 2). Penuel, Lee, & Bevan (2014) emphasized the need for science and engineering practices to develop students' agency and be co-constructors of their futures and for society. Barton (2001) explained and exemplified these ideas through her use of place-based learning of science with urban students. For each of the authors above, the importance of science and engineering practices in education is to offer students insights into their own agency and ability to transform society.

Methods

This qualitative case study tells Janet's story as she integrated engineering-based lesson into her physical science class. As a qualitative case study, the focus is on how she described her thoughts and experiences (Merriam, 2009). I have presented Janet's story through the use of constructed themes to better highlight the changes in Janet's thinking, since, as Stake (1994) explained, "most personal experience is ill-structured, neither pedagogically nor epistemologically neat" (p. 146). Therefore, ideas must be organized and structured for presentation. Prior to the full case, I describe the context followed by the data instruments and analysis.

Context and Participant

Janet was a participant in a two year professional development (PD) experience offered by a local university and funded by the National Science Foundation (NSF). The teacher participants for the extended PD experience came from one of eight partner school districts. Janet was a member of the second cohort of 20 secondary science and mathematics teachers participating in the program. The biology teacher, Claire, from Janet's school was also a member of the cohort. Janet and Claire were friends as well as colleagues and worked closely with each other throughout the PD program. Janet and other teachers in the cohort came to campus for seven weeks for each of two summers. During the summers, the teachers participated in engineering and disciplinary coursework, pedagogical workshops, and unit design sessions. The teachers were expected to develop three engineering units each summer, which they then implemented and revised during the academic year. Janet was one of a subset of the PD participants who volunteered to participate in a research study connected to the program. I served as a researcher for the program.

The PD program was developed by a team of engineering faculty, disciplinary science faculty, and retired secondary mathematics and science teachers. The PD design team used a Challenge-Based Learning (CBL) framework to structure the engineering design process. A CBL environment provides a motivating problem to solve that address a larger societal issue in which the engineering design process (EDP) is embedded within it. Thus, a focus on CBL closely aligns with a humanistic approach to engineering. The goal of the PD was for the teacher participants to develop engineering based units where students would grapple with a complex problem rooted in a larger social issue that integrated the required science content in engineering design process (Johnson, Smith, Smythe, & Varon, 2009).

Janet, African American teacher in her mid-forties, was born in the same city where she is now teaching. In 1987 she graduated from the district's academic magnet high school, then went away for college. She received her BS degree in chemistry from a Historically Black University in the Southeastern United States in 1991. After graduation, she worked as a product researcher for ten years before returning to school to receive a secondary science teaching license. When she began the engineering PD, she had been teaching for ten years and was the science department head at her school, Mid-City High School. She had taught science at Mid-City for seven years and was considered a school and district leader by her teaching colleagues and district curriculum coordinator. Janet's primary teaching assignment, and the focus of her engineering lessons, was a required physical science class.

Mid-City High School was part of the district's portfolio of high schools; any student in the district could select to attend Mid-City. Although, in reality, the majority of students came from four nearby elementary schools. Mid-City served students in grades 7-12. The September student count was approximately 700, 75% of whom qualified for free or reduced lunch, 95% identified as African American or multiracial, and 27% were on a disability plan. Although the students' performance on State mandated tests was lower than the district's average, they had been improving over the last four years but were still lower than the State's proficiency levels.

Janet's classroom was on the second floor of the school, which had been newly built in 2007. The school had well-equipped science classrooms and resources. Mid-City and the district as a whole had moved to a one-to-one laptop program; however the laptops remained in the teachers' classrooms rather than being assigned to a student. Janet's taught five classes of physical science with class sizes that ranged from 18 to 32 students. All classes were inclusion classes, although the special needs students were clustered in two classes.

Data Gathering and Analysis

The data were gathered from June 2013 through May 2015. The full data set included a survey given twice, two structured interviews, three semi-structured interviews, nine classroom observations, teaching artifacts, and student work.

At program entry and exit, Janet completed a Current Instructional Practices (CIP) Likert response survey that asked how frequently and how confident she felt about teaching practices related in engineering and CBL. The survey stem for frequency read, "To what extent does your current instruction incorporate these practices" and included items such as:

- Explicitly connect class content to complex problems
- Guide students in planning investigations to better understand different components of problems
- Provide opportunities for students to test their solution pathways
- Provide students with opportunities to refine and retry a solution pathway

At program entry and during the second summer, a structured interview, Conceptions of Teaching Engineering (CTE), was conducted. The CTE interview was modeled on Hewson and Hewson's (1989) conceptions of teaching science modified for engineering. The interview consisted of eleven teaching scenarios. For each, Janet was asked if she considered the scenario to be an example of teaching engineering and what told her it was. Or if she did not consider it an example of teaching engineering, to explain what would be needed for it to be teaching engineering? Example scenarios included:

- In an 11^{th} grade physics class, the students use a rocket kit to build a compressed air rocket.
- After an accident in the school parking lot, the teacher for an after school enrichment project decides the group should develop a traffic regulation system.
- A math teacher has students measure the water wasted by a dripping faucet in a 10 minute interval then create a linear equation to represent the data.

During each academic year, one unit implementation was observed and one post-unit interview conducted. In the interview, Janet was asked to reflect on how she felt the unit went, where she and her students were successful, and where she felt they struggled. At the end of the two years of PD, a final exit interview was developed based on themes and questions arising from the previous data. In addition, she reflected on how she felt the PD impacted her as a teacher. Instructional artifacts, such as lesson plans, handouts, and student work, were available if needed.

The analysis was conducted in phases: program entry, year one implementation, second summer, year two implementation, and program completion. Each phase resulted in themes and written summaries. The summaries were used to guide future observations and construct the final interview in an iterative process as is standard with qualitative studies (Merriam, 2009).

Interview and observation data were initially coded with pre-determined codes guided by the CBL literature with three general categories: engineering, student/learning, and teacher. The general categories focused on the subject of the coded item. The categories were then further coded to understand the details of the general categories. Table 1 provides examples of the categories, codes, and use.

Table 1: Sample codes from interviews and observations

Category	Code	Example
Engineering	Design process	I think about a process of being clear about what the problem is, designing and redesigning to apply skills and knowledge to a problem.
	Parameters	Now like in some classes our budget is only for mini-marshmallows and toothpicks.
	Products	I can build a better bike
Student/ Learning	Decision-making	They're doing prototypes or do a prototype and then go back and do more brainstorming
	Evaluating	Determine if it meets the criteria that they have developed.
	Data gathering	What variables need to be controlled? I mean if they look at one variable at a time …
Teacher	Problem context	It could be an example of teaching engineering, if the problem is applied to a building … or some type of technical problem.
	Applications	I think I did not do as good a job as I could have in having actionable components.
	Assessment	The teacher might be gathering some data as a formative assessment to see if they are on the right track.

The CIP survey questions and codes for the CTE interviews focused on similar ideas, which allowed for comparison between how Janet rated her own teaching practices and what she believed constituted good engineering teaching practices, and her stated comfort level with the different aspects of CBL practices and her observed implementation of the practices. Janet had access to all data during the process and was sent each summary statement at the end of an analysis stage, as well as the full set of summary statements leading into the creation of the case. Janet did not provide any feedback or offer suggestion or revisions.

Findings

In the first year, Janet's engineering focused lesson took place during the physics unit on energy transformations. The global challenge she identified was on forms of renewable energy to reduce reliance on fossil fuels contributing to global warming (Lesson plan 3.0). The specific classroom challenge she wanted her students to engage in was to create a Rube Goldberg machine to do work without using electricity. In the second year, Janet's focal unit was from the chemistry component of physical science and focused on mixtures and chemical changes. The global challenge she focused on was the development and maintenance of effective infrastructure, and her local design challenge was for students to develop a strong and cost-effective concrete mixture for a local bridge.

Overall, Janet's beliefs about the role of engineering in her science instruction focused on two primary themes which arose across the data sets and are relevant to understanding her ideas about using engineering in urban classrooms. These themes and their changes over the two years included her beliefs about the nature of engineering and the teaching and learning of engineering.

The Nature of Engineering

Janet's initial discussions of the role of engineering in her instruction stressed the differences she perceived between science and an engineering challenge. For Janet, the purpose of teaching science was for her students to understand the content and be able to perform simple inquiry activities. Science inquiries were driven by a structured hypothesis, whereas engineering challenges were being driven by problems. Also, the problems that engineers engaged in were technical, as she explained in her first interview: "It could be an example of teaching engineering, if the problem is applied to a building, developing a building, or if it is applied to some kind of technical problems" (Int. 1 lines 124-128).

Since engineering was problem driven, it provided an interesting context for using science content: "I think if they can see how it applied in a real-world problem or a real work situation, then it is engineering because they're solutions to problems and not just learn content" (Int. 1 lines 342-344). Later she stated, "I definitely think that's engineering because they're figuring out a problem. They're applying the content to a problem about getting maximum speed" (Int. 1 lines 392-394).

Janet explained the relationship between science inquiry and engineering design in response to a question about graphing the rate of a leaking faucet:

> As is, it's not an engineering project, but it could be, if they were asked to use that data to solve a problem from there, like, since we're [with a leaking faucet] wasting this much water … you're still measuring the faucet dripping, you're still plotting data, I think this is just the data collection stage of the process, because it's [engineering] tying into some bigger problem. (Int. 1 lines 316-321)

In her early thinking, Janet highlighted engineering as involving problems that helped connect science content to the real world.

The use of a general problem, rather than student experience-based problem, was also reflected in her first year's lesson plans. For the global challenge, she situated energy transformations with forms of renewable energy leading to a reduction in fossil fuel use leading to global warming (Lesson plan 3.0). However, her specific in-class design project was to create a Rube Goldberg demonstrating at least three energy transformations (Lesson plan 3.0). The students were introduced to a Rube Goldberg device via a YouTube video of a competition (http://www.youtube.com/watch?v=WiHn5_RfKjE). Although the video is interesting and clearly presented a challenging design task, the application to the real-world problem and the students' needs or experiences was distant.

During implementation, Janet's teaching drifted further away from engineering as a way to address human problems when she allowed her student to design roller coasters as long as they met the science content (energy transformations) objectives (Obs. notes. 4/1/14 – 4/11/14). In the post-observation interview, Janet explained how in each class some student groups argued for alternate design task, such as roller coasters. As she reflected on this, she acknowledged that many of the students did not see the connection of the Rube Goldberg device to a real-world problem.

> I feel like we missed the boat. I think we tried initially but kind of lost our way because

> we just focused on making sure the students engaged. We know that they're engaged. They're probably learning or we hope they're learning, but the intent of having deeper and stronger connection to the world, I think we missed that. So that's something we have to think about. (Lines 24-32)

Janet's reflection on the lack of a strong connection to a real-world problem is the beginning of her shift towards a more humanistic approach to engineering as part of her understanding of the nature of engineering. In her second engineering interview, she expanded the nature of engineering to include solutions based on people's needs. For example, in a question about food production she said, "maybe they developed criteria based on what their customer base is" (Lines 85-86). She suggested engineering could include economics as she explained knowing this would focus the research for students: "But you know whatever the criteria is, they choose to make it, they choose to sell it, they may do some research" (Lines 87-89). And later, "some cost-benefit analysis to talk about feasibility" (Line 203). Finally in this interview, she discussed that communities and ethics around ecology would need to be part of the decision-making about the engineering problem of a dam construction.

In Janet's second year of implementation, she began to explicitly tie her engineering problems to her students' experience base and community. Janet's engineering lesson was tied to her science curriculum as part of the chemistry content on mixtures and reactions. Her design task at the global issue idea focused on infrastructure development; however what she stressed was the local need for new bridges. She focused on several local bridges that had been in the news due to their needed replacement. With this specific and local context in mind, the students brainstormed all the problems with infrastructure development in an urban setting. The students raised issues including: traffic disruption, potholes, homes to be destroyed, costs, taxes, tolls, noise, and pollution created during construction. They related their own experiences with being late for school because of road closures or friends who couldn't open windows all summer because of dust from road construction. Once these personal experiences were on the table, Janet shifted to the classroom engineering problem the students would address as part of this bigger network of problems. The next day, the students brainstormed and researched what might be important variables to consider for the cement in the local environment. The students identified variables such as, traffic volume, salt and snow plowing, cost, accessibility of the materials, the look of the bridge, amount of space it would take up, and other style issues. Finally, Janet brought the focus on the issue of traffic volume and concrete composition and how they were going to design the best concrete for the traffic volume (Obs. notes 1/25 - 27/15).

In this second year of implementation, Janet's view of the nature of engineering encompasses all components the engineering as a humanistic view of engineering. The students connected their experiences with infrastructure to the design task. As the students worked on the concrete, she continued to return to her students' experiences, reminding them it was important to be careful as they would have friends and family driving across these bridges.

In her final interview, Janet reflected on the importance of having the students understand that engineering addresses problems in their lives and community. She felt it was important for her students to see local impact of engineering so they could understand how engineering impacts people throughout the entire design process and not just as a completed product.

Janet's ideas about the nature of engineering became more complex over the two years of the project. Her initial views fit perfectly within a standard view of engineering as the use of science and mathematics knowledge to overcome problems. She drew on her science background as her first lens for understanding engineering, comparing the processes of science with the processes of inquiry. But as she became more familiar with engineering and observing and reflecting on how her students interacted with her design challenges, she was ready to expand her vision of engineering to include and emphasize the human side of the process. The shift from viewing engineering as a simple application of science to engineering as a complex human activity is one step toward using engineering for social justice. The second step is detailed in the next section.

Teaching and Learning with Engineering

In Janet's first year, she placed high value on engineering tasks to increase student engagement, which she believed would improve her students' learning as defined by specific content goals and objectives in her lesson plans. As such, in the action of the classroom, she focused on engagement over learning outcomes. In her first unit on energy transformations, Janet allowed the students to drift from the intended Rube Goldberg machine defined in the engineering task to other products. In her reflective interview indicated the freedom she gave the students was positive, "… some kids said I don't want to do that. That's not challenging enough for me. They broke off from the class and said I want to design a roller coaster" (Lines 120 – 122). However, after the end of the unit test she lamented, "They have a big picture of it [the content] and they may realize they're using the information but then when you ask for it in another form, they can, the gap is too big" (lines 1089-1091). The lack of expected learning as demonstrated on tests worried Janet and helped her to rethink what she wanted in terms of engagement, relevance, and learning. She stated, "this summer I am going to be thinking about a little harder [sic] about how I can make it more relevant to them" (Lines 314-315).

In her second year of implementation, in addition to focusing on problems important to the local community, Janet expanded what she valued about the learning. She did not drop the importance of understanding the science, but she also focused using the engineering design process to solve social and community problem, build her students' confidence, and their role as citizens.

Two specific examples demonstrate how Janet worked to directly connect the engineering design process to strategies of Dr. King portrayed in the movie *Selma*, which the class had seen the previous day. Janet drew the students' attention to the conflicting points of view about civil rights and how this was similar to addressing the pros and cons of where a bridge should be located (Obs. notes 2/5/2015). In another instance, she discussed how her engineering unit had led to a collaborative design project focused on infant mortality, a high priority health problem in the city:

> At the end of the school year, our challenge was to look at infant mortality. So I proposed to the team that we do an interdisciplinary unit … so we developed a challenge to see what can we do, can we look at co-factors that are affect infant mortality as it related to science and social studies…. But the challenge really came out of our classroom, which was what can we do to minimize environmental factors related to infant mortality? (Lines 876- 893)

Janet was not only expanding what she included as engineering, she was using engineering to help her students see how the design process is a powerful tool for solving complex problems in and out of science.

In addition to learning science and the engineering design process, Janet also wanted her students to be successful even if it meant taking risks. In the post observation interview, Janet explained why she believed it was particularly important for her students to be successful: "I know students feel, and they have shared with me, they're at a disadvantage because of resources and being in urban schools and I kind of hate that that's been communicated to them" (Lines 429-435). She felt the students lacked confidence to take on challenging problems. Janet explained how the idea of freeing up her students' thinking about right and wrong answers had impacted what she did and wanted to do her classroom:

> They can't, students would often answer, well I don't want to answer because I might be wrong. So really developing a culture of risk-taking, that's something I think I had to focus on the second year, to allow students to make mistakes and to constantly say, okay we may make mistakes, but it's part of the process. (Lines 68-72)

For Janet, allowing her students to work on complex problems was a demonstration in her confidence in them that they could be successful and could build from these successes for the future. She discussed her final priority as helping her students work through complex problems since her teaching was not just school but for their futures as citizens:

> If you put words like ethics around it, I think it would change the way they think about it. They would think about a responsibility, not just as a citizen in the classroom, but they think about it as their responsibility in the world. (Lines 555 – 557)

Over the two years of the project, Janet's use of engineering as a tool for improving her students learning reflected her changing view of the nature of science. She increased the complexity of the thinking she required of her students by intentionally muddying the problems with the inclusion of economics, psychology, sociology, and ethics. She wanted the students to see engineering not just as a way to make good concrete, but as an integral part of the design of communities. Once Janet included the humanistic side of engineering into her framework, her goals for her students' learning expanded also.

Conclusions and Implications

Janet's initial ideas of engineering focused on the importance of engineering for people to overcome problems in the world; however, she struggled with how to define appropriate problems for her students. Over the two years, Janet revised her thinking and focused on meaningful localized design tasks that fit her students' knowledge and experiences. Local community problems served as the hook and the anchor for the design task which were then connected to larger global and abstract problems. This focus on local issues aligned her view of the nature of engineering with Hynes and Swenson's (2013) humanistic approach to engineering. In addition, it aligned her teaching practices with place-based urban science educators like Lim and Calabrese Barton (2006) and Penuel's vision of engineering as social practice. A second shift in Janet's beliefs and practices addressed the limitations of engagement as an outcome. The students engaged with the "fun" parts of design, but seemed to resist the hard work of learning. Janet felt her students had internalized messages from the larger society that urban African American students were not good at solving complex problems and did not see themselves as active agents in their communities. Over the two years, Janet introduced the idea to her students that they could be the agents of change and the design process was a way to organize thinking towards making change.

The stated purposes for integrating engineering into science curriculum are focused on laudable cognitive goals for students and the STEM workforce (Crismond, 2001; Jacob and Parkinson, 2015). However, like much of science, it is presented as politically neutral. Even Challenge-Based Learning, which is premised on the idea that students would find global problems compelling to study, does not emphasize a political stance. What Janet's case demonstrates is the potential of a humanistic approach to teaching engineering to develop teachers' and students' understanding of issues of social justice in their local communities. Janet did not just learn to use engineering as an instructional strategy; she articulated a new imperative for herself as a teacher and her students. She believed it was not enough for her students to do well in school only as preparation for college or careers; they should be empowered to tackle the problems of today in their own community.

I am not suggesting integrating humanistic vision of engineering is the only answer to creating cadres of critical educators for our urban students. However, if the integration of engineering into science instruction can result in experienced teachers shifting their focus to a more place-based curriculum with a social justice focus, it can be a powerful tool for reinvigorating urban teaching and breaking the cycle of a reductionist curriculum.

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