JOURNAL OF RESEARCH IN SCIENCE TEACHING VOL. 38, NO. 3, PP. 337–354 (2001)

Representing Student Achievements in Science

Dana Fusco,[1] Angela Calabrese Barton[2]

[1] *City University of New York, York College, 90-20 Guy R., Brewer Blvd., Jamaica, New York 11451*

[2] *University of Texas at Austin, 340 Sanchez Building, Austin, Texas 78712*

Received 10 January 2000; accepted 27 October 2000

Abstract: In what follows, we develop a conceptual argument for expanding current visions of performance assessment to include the following three ideals: that performance/assessment addresses the value-laden decisions about what and whose science is learned and assessed and include multiple worldviews, that performance/assessment in science simultaneously emerges in response to local needs, and that the performance/assessment is a method as well as an ongoing search for method. To make this argument, we draw together ideas raised by critical, feminist and multicultural science educators to describe an inclusive science education, one we refer to as critical science education, to raise questions about the nature and purpose of performance assessment in science education. We are particularly interested in how the science of assessment is challenged and transformed within a critical science education perspective and the conditions needed to create an equitable and inclusive practice of science and science assessment across diversity. We present a case study from a youth-led community science project in the inner city to help contextualize our argument. © 2001 John Wiley & Sons, Inc. J Res Sci Teach 38: 337–354, 2001

Different things you can do in the garden

1. Sit down
2. Walk around and look at flowers
3. Weddings & family reunions
4. BBQ & Cookout
5. Running around & playing tag
6. Have talent shows & concerts
7. Help (planting & cleaning)

What children could do in the garden

1. Play with their toys
2. Run around

Correspondence to: A.C. Barton
Contract grant sponsor: National Science Foundation (ACB)

3. Jump around on the stage
4. Look at the pond

New Inventions!!!

1. Sandbox
2. Playpen
3. Map of the garden

(Entry #17, Excerpt from *The Book*, April 12, 1999)

Over the course of 9 months, we worked with young people residing in a long-term homeless shelter in New York City twice a week designing and implementing a community-based science program. (One of us [Dana] did most of the planning, teaching, an assessment development for this project [Fusco, 1999]. One of us [Angie] did most of the participant observation and interviews with the involved youths.) One major goal of this practice was to transform an empty lot across the street from the shelter into a usable/public space for the community. In designing this space, months were spent brainstorming and researching ideas on the Internet, in books, and through interactions with professional gardeners, architects, and scientists, deciding what was feasible, locating resources, conceptualizing designs, and communicating our plans with the broader community. As we had learned from an experienced landscape designer, one question to consider during the design process was, ''What activities do you want the space to support?'' The youths first examined ''the different things you can do in the garden,'' which included sitting down because they would have benches, having talent shows and concerts because they would have a stage, and planting because they would have a garden. In discussing the activities available for young children, the youths added new inventions (a playpen and sandbox) to their design when they recognized that infants and toddlers had not been considered in their plan.

The Book, from which the above excerpt was taken, is a document cogenerated by the youths to record and display the collective history of their efforts to transform the lot, and a document cogenerated by us as an emergent assessment tool. We share this excerpt because it raises questions not only about what the youths accomplished and learned through the project but also about how as teachers we might better understand the youths' growth and development within (and outside) the domain of science education. For example, what is new or inventive about a sandbox, playpen, and map of the garden? Where is science in any or all of these activities? Whose achievements are represented in these inventions? What constitutes the achievement and how would we know when we witnessed it?

In what follows, we first describe critical science education, an inclusive vision of science education which draws on the ideas raised by critical, feminist, and multicultural science educators. We use this critical science education perspective to raise questions about the nature of science and knowing in science, the relationship between science and society, and the implications these belief structures have for how we view science as a school subject. We then use the insights gained from these perspectives to specifically address equity and diversity in assessment and describe our own attempts to imagine an assessment tool that is both a means for understanding the enactment of critical science education as well as a method for rethinking the nature of performance assessment in science. We believe that in the context of critical science (a) the performance/assessment must address the value-laden decisions about what and whose science is learned and assessed and include multiple worldviews, (b) the performance/assessment in science emerge simultaneously in response to local needs, and (c) the performance/assessment is a method as well as an ongoing search for method. To substantiate our argument, we draw on the experiences of the youths briefly described here and the book they cogenerated to explore the question of assessment in science education. We conclude by examining how theory and practice inform our understanding of critical science education and assessment in science and address the questions—how is the science of assessment challenged and transformed within a critical science education perspective, and how does this understanding help to create an equitable and inclusive practice of science and science assessment?

Critical Science Education: Raising Questions about Assessment

Reform initiatives in science education in the 1980s and 1990s squarely positioned science as a social process and cultural practice with particular ways of knowing and doing science (Maerican Association for the Advancement of Science, 1993; National Research Council, 1996). In the past decade there have been numerous research articles which draw from theoretical traditions (critical, feminist, multicultural, and poststructural theories), as well as from these reform initiatives, to challenge the positivistic foundation of science and school science as a basis for understanding issues of access, equality, and excellence in science and science education. Although each theoretical tradition uses a different analytic lens (i.e., critical theory: class; feminist theory: gender), all of these traditions raise fundamental questions of power, knowledge, and production in science and schools. The driving goal of these efforts has been to construct images of a more inclusive science education, whether exclusivity is defined in terms of race, class, gender, or other marginalizing labels or identities.

Drawing in a comprehensive fashion from these diverse perspectives we have attempted to pull together the common threads. Namely, critical science educators have pushed the debate surrounding inclusive science education forward in terms of how we understand the nature of science and knowing in science, the relationship between science and society, and science as a school subject. In what follows we begin to examine these three domains and describe our understanding of how the science of assessment might also be transformed within a critical science education. A summary of these ideas can be found in Table 1.

The Nature of Science and Knowing Science

Critical science education draws from the feminist and multicultural belief that science is a subjective but rigorous and reflexive approach to making sense of (and building stories about) the world. It views scientific knowledge as constructed through social acts where individuals interact in distinctive ways with society and culture to create something for some purpose (Gill & Levidow, 1989). In other words, the production of scientific knowledge is linked to the social uses of and needs for scientific knowledge (Harding, 1998; Young, 1989). Critical science education therefore reasons that the knowing and doing of science are historically, socially, and politically situated processes. What scientists know and how they have come to know it are artifacts of the context in which scientists work. Furthermore, the scientific agenda is informed by a community greater than just scientists. Scientific research is influenced by the overall research context, the specific research situation, and the historically situated ways in which scientists act, think and work (Lave, 1988; Roth & McGinn, 1998). One can never know or do science separate from his or her own history (individual and societal). Although one can try to understand his or her own history and how it might influence how s/he comes to know the world, science and history can never be fully separated. Such a perspective about knowing and doing in science is in contrast to the traditionally accepted vision of science as an objective enterprise.

Table 1
Critical science education and assessment

	Critical Science Education	Questions for Performance Assessment
The nature of knowing in science	• Scientific knowledge is a human made explanation of how the world works, and is thus subjective yet rigorous and reflexive. • Concepts, although rigorously tried, are culturally based and need-based explanations of natural phenomena to be applied in everyday activities. • Science is a social activity and involves understanding how human values and characteristics shape scientific knowledge.	• In what ways can the assessment of performance represent the holistic and historical nature of knowing in science? • In what ways can inventions and performance assessments be infused with the worldviews and perspectives that particular students bring to the learning and doing of science?
The intersection between science and society	• Science has an ethical responsibility for the knowledge it produces about the world. • Scientific concepts emerge from dealing with societal problems/real life and the needs of the local community, which are seen as fundamental to the creation and production of science.	• In what ways can performance assessment emerge from individual and collective responses to local concerns? How can such responses be both the production of science and the production of assessment?
Science as a school subject	• The teaching and learning of science ought to contain elements of action and change, i.e., learning is not just an academic task, it is about interacting with/in the world. • Science teaching and learning should include the content, process, histories, norms for participation, and discursive practices, • Students should be viewed as users and producers of science.	• In what ways is performance assessment a method and a search for methods? • In what ways can performance assessments include young people in their creation, and thus infuse how young people do and talk science in the context of community?

Similarly, "to see assessment as a scientific, objective activity is mistaken; assessment is not an exact science" (Gipps, 1999, p. 370). Assessment is also value laden and socially constructed. Newer forms of assessment are grounded in this socially constructed perspective. For instance, performance-based assessments are in vivo assessments of actual performance showing what a student can do, rather what a student can skillfully recover from memory. Students may be asked to design a protective container for an uncooked egg using the concepts of force, motion, gravity, and acceleration. The performance is the assessment and provides multiple opportunities for teaching and learning (Wolf, Bixby, Glenn, & Gardner, 1991) by transforming classroom environments into places where collaborative inquiry and problem solving are the norm, rather than the exception. Learners participate in knowledge building communities where meaning is coconstructed, discussion of new ideas and multiple modes of expression are fostered, and the culture of expert practice is created and maintained through collaborative problem solving in authentic and relevant activities (Rogoff, 1990). The assessment should help to create "a learning environment in which students are engaging in learning activities consistent with current psychological, philosophical, historical, and sociological conceptions of the growth of scientific knowledge" (Gitomer & Duschl, 1995, p. 1). Here, the curriculum reflects what scientists do, including the fluid aspect of their work. The goal is "to move from the initial diversity of ideas existing in a classroom to a view that represents a consensus by virtue of its scientific plausibility" where the assessment reflects this shift (Gitomer & Duschl, 1995, p. 20).

Performance assessments have played an important role in challenging how we define good science learning and achievement in the classroom by raising fundamental questions about what it means to know and do science in individual and group contexts. Questions such as, "Whose knowledge are we teaching, and whose knowledge are we assessing?" and "Whose knowledge and way of knowing is of most worth?" challenge our understanding of science and of assessment in science because they imply that scientific inquiry and knowledge develop in relation to cultural and historical contexts, both inside and outside the classroom. They represent an epistemological shift where knowing/knowledge is constructed in relation to the world rather than alone in one's mind (Gipps, 1999; Sfard, 1998). That is, they draw our attention to the fact that "scientific knowledge emerges from a nexus of interacting people, agencies, materials, instruments, individual and collective goals/interests, and the histories of all these factors" (McGinn & Roth, 1999, p. 15). Measuring individual mastery of knowledge therefore often deletes the process by which science is produced and fails to represent science as a cultural and historical process and product. Those with access to particular ways of participating in science and in school science are credited with superior mental acumen and achievements. Those that bring multiple worldviews and ways of knowing to the production of science are often misrepresented (Roth & McGinn, 1998). We ask, in what ways can the practice of science and assessment of performance represent the holistic and historical nature of knowing in science? In what ways can performance assessments be infused with the worldviews and perspectives that students bring to the learning and doing of science?

Intersections between Science and Society

In addition to understanding and questioning the nature of science and scientific knowledge, a critical science education perspective suggests that it is important to make visible how science is situated within larger social values and global ecosystems. Scientists' aim since the 17th century has been the control and the domination of nature (Keller, 1985). This authoritative and controlling stance has helped catapult science into the category of invincible. Yet, feminist and multicultural scholars suggest that science should not be an exercise of domination, but rather one of equity (Gill & Levidov, 1989; Keller, 1985). Science and science education are situated within their representations of the natural world and their set ways for regulating meaning. This situatedness is central to understanding how dynamics of power and privilege structure the daily life of society. Scientific concepts emerge from dealing with societal problems and real life, which are seen as fundamental to the creation and production of science. Viewed from another angle, this can also be read as science as a social practice with social responsibilities (Epstein, 1997). For example, Cynthia Cohen (1996) described how the development of reproductive technologies in the United States, and in particular the process for egg donation, is inseparable from the needs of the mother, the donor, and the doctor, as well as the ethical and moral implications in a technologically advanced and socially conservative society. Critical science underscores the stance that science and scientists have an ethical responsibility for the knowledge and changes science produces in the world.

The results of assessments, like those of science, because they are situated in human made explanations, also have real-world repercussions and outcomes. Creating an inclusive and equitable science assessment must equally consider how the results of such assessments inform students (and parents) of their abilities in science. Kulm and Stuessy (1991) suggested that alternative assessments can break down the barriers to mathematics and science by way of reporting students' progress in understandable terms. As students discuss various science projects using common household objects, perceptions of science change. We argue that science for personal and social purposes might go further to include the local dialogues and lived experiences of those asked to engage in science-based endeavors. One way of connecting science to students and society is for scientific concepts to emerge from dealing with societal problems and needs of the local community. Performance assessments, because they require student-centered, inquiry-based practices, hold the potential to transform the nature of science and pedagogy in science from one that is fact focused and contextually abstract to one that is emergent from real-life problems and the needs of local communities. Articulating local concerns, then generating and enacting informed and productive responses to such concerns is at once an enactment of science and an assessment of one's ability to productively engage in local scientific practice. The assessment, rather than deleting the achievements of marginalized groups in science, would reflect and help create equitable practice in science education by virtue of its embeddedness in the coproduction of meaningful and relevant science activities.

Science as a School Subject

In traditional science classrooms, contradictions often exist between the unproblematic way in which science is presented and the ways in which students' gendered, raced, and classed values are a part of their own construction of science (Atwater, 1996; Barton, 1998; Brickhouse, 1994; Lee & Fradd, 1998; Rodriguez, 1998). These contradictions, because they are often unarticulated and unrecognized, teach students that if standard ways for engaging in science do not make sense, feel right, or connect to their experiences, they are the ones who are wrong or intellectually deficient. Students are expected to make sense of the world in prescribed ways; they learn to impose boundaries, constraints, and definitions on themselves, others, and the world. In short, they learn that a lack of diversity in the ideas and ways of knowing is what is acceptable in science.

There is widespread agreement among feminists, critical, and multicultural science educators that students need to have access to the domain of Western science, even if it has little relevance to the lives of students most on the margins of school science (Atwater, 1996). However, such access must occur in ways that are culturally relevant to students. Critical science education supports pedagogical strategies that build with the ways of knowing brought to school by students, such as caring, cooperation, and holistic approaches, even when those ways of knowing are not obviously part of science (Barton & Osborne, 2000; Roychoudhury, Tippins, & Nichols, 1995). Also supported are strategies which seek to incorporate communication processes reflective of the lives and cultures of students which may be present in the classroom, such as oral narratives and storytelling (Atwater, 1996). Furthermore, Atwater (1996) argued that science educators need to use—and help their students to use—a "critical lens" to question how scientific knowledge is learned and produced, and the ways in which classroom practice links (or does not link) science education to "self" and "social empowerment" (p. 823). Teaching science cannot be reduced to the acquisition or mastery of skills or techniques but must be defined within a discourse of human agency. The teaching of science occurs within the larger contexts of culture, community, power, and knowledge. Science teaching therefore must respond to the political and ethical consequences that science has in the world, and must be equally infused with analysis and critique as it is with production, refusing to hide behind modernist claims of objectivity and universal knowledge. Teachers help to construct the dynamics of social power through the experiences they organize and provoke in classrooms.

We build on this position and argue that if science education is fundamentally about interacting with/in the world in informed, reflective, critical and agentic ways (Rodriguez, 1998), any construction of an assessment must draw on those same qualities to be authentic as well as inclusive of the whole of doing science. Thus, developing performance/assessments in science involves both creating and then capturing the ongoing process by which tools are developed, refined, and redeveloped to craft responses within the co-production of science. (We use the phrase *performance/assessment* to stress the link between the method and the ongoing search for method and that both coemerge in the process of doing science.) The development of the assessment thus is both a method and an ongoing search for method. In an ongoing search for method, tools are continuously created in relation to ongoing changes in the group, its goals, activities, interests, and outcomes. What we are arguing for here is that performance/assessments, in the rich contextual detail in which they are presented to students, cannot be fully constructed in advance of an articulation of a community's particular needs and without the students' involvement in defining the nature of those needs. It is not that many of the assessment objectives cannot be known beforehand—we agree that they can, i.e., particular computation or mapping skills, certain conceptual understandings. However, one of the biggest challenges in teaching is that we never teach anyone who is exactly like ourselves. There will always be differences in experiences, beliefs, and understandings. Thus, we cannot know in advance the ways in which objectives for science learning/doing may come together through student action and response to local conditions and how that coming together then reframes the essence of the objectives as well as the enactment of those objectives. The assessment must emerge and develop alongside the enactment of local objectives and themselves are equally enacted. That is, the assessment is also a tool and students must equally be involved in deciding on the nature and purpose of the assessment, in producing as well as using methods. Involving students in this process thus also includes the ways that students do and talk science in the context of community. The content, process, and discourse of science are created with what the young people bring to the production of science and assessment.

In short, we believe that consideration of critical science education has major implications for how and why we think about performance assessment. Although our own work was not situated in a school, we believe it has implications for how teachers can make stronger connections between school science and community by situating assessment in activities which connect students to science and society in meaningful ways. We are particularly interested in what happens when the performance assessment itself allows not only our understandings of learning to be challenged, but also our understanding of the nature of science and the intersections between science, students, and society. We are also interested in how our understanding of critical science challenge the possibilities (and limitations) of performance assessment. In the next section of this article we examine a case study of doing science and assessment with youths living in the homeless shelter. We use this context to examine what it might look like when such a critical science perspective is brought to bear on performance assessment. Essential to this discussion is the impact that such a perspective has on concerns around diversity, equity, and science for all. Here, the nature of scientific inquiry and assessment was recursive and dynamic; science was collectively produced by the young people in the service of community where the assessment reflects this collective achievement; and the educational goals of both the practice and assessment emerged in relation to the particular interests, concerns, and lived experiences of the homeless youths with whom we worked.

A Vision: A Case Study of Performance Assessment with Homeless Youths

The Context

We have been teaching and researching homeless youths in urban settings for the past several years. One aspect of this work has been to collaborate with a group of middle and early high school students in action-research–based activities ranging from community gardening to video production to youth-to-youth interviews. All of the teens (ages 12–16) lived in the same homeless shelter in New York City with their families for varying amounts of time (6 weeks to 15 months). For the majority of the teens, this was their first experience as a homeless person. All of the teens except one attended local New York City public schools. The one teen who did not attend public school did not attend school at all, although he had not officially dropped out of school.

The shelter where these youths live is located in a section of the city known for its toughness and economic decline. It is a large shelter, housing over 200 families, and takes up an entire city block. It is nestled between one of the city's largest comprehensive public high schools, a city park that the youths describe as dangerous, apartment buildings, and an abandoned lot. The majority of the youths, although thankful they have a place to live, hate living in a shelter. Interviews of 15 of the youths reveal the unanimous opinion that the shelter feels like prison. It is completely surrounded by iron fences. The security guards treat the tenants as if they are lower forms of life. Visitors, including immediate family members, are not allowed on the shelter property, except in the lobby's waiting area by the guard's desk, although as one youth, Darkside, stated, "not that I would even want to [have friends over] at a shelter." All shelter residents are required to sign in and out and are held to strict curfews: 9 p.m. for children under the age of 12, 10 p.m. for children under the age of 18, and 11 p.m. for adults. Families are allowed to break curfews twice, but the third break in curfew results in immediate (24-hr) eviction from the shelter. Children and youths under 18 are not allowed on shelter property at any time without an adult guardian. Thus, for example, if a parent is at work or elsewhere, children cannot go home. However, this particular shelter, unlike other city shelters, does offer educational and health programs for children and parents including such things as after-school activities, a computer room, Graduation Equivalence Diploma courses, and various seminars on financial management, street safety, and healthy eating.

The Science Program

The project described here involves the transformation of an abandoned city lot into a community garden by the youths in the shelter we described. It occurred in collaboration with an after-school program operating out of the shelter. The project began in October 1998 and occurred twice a week. Over a 9-month period, at least 40 children and teenagers were involved in at least one project activity. In any given quarter (or 9-week period) there were approximately 20–25 participants, half of whom were core participants or attended the sessions regularly. Many of the participants were boys (approximately 68%) because fewer teenage girls were enrolled in the after-school program. The participants were predominantly African American, Caribbean American, Latino, and biracial.

The community-based science project had several objectives. The first objective was to work with the youths to articulate their concerns and the concerns of young people today. We used their understanding of the social and natural world to begin formulating possible action plans (i.e., the lot transformation). The second objective was to involve the youths in the practice of science, including such things as asking good researchable questions, seeking out and using meaningful resources, generating and collecting data, deciding how and when to use those data, and using basic scientific skills such as observation, calculation, mapping, classification, data collection, and analysis. The third objective was to develop a performance assessment that reflectively emerged from our understanding of critical science education and thereby would develop alongside the production of science.

Even though we initiated the project and held overarching objectives, after our initial meetings the day-to-day goals and purposes of the project were strictly up to the teens. We began by talking with them about their concerns. The youths made murals and role-played, expressing their interests and concerns in multiple ways. They talked about gangs, school, personal relationships, teenage pregnancy and drug use, among other things. These activities quickly reflected the daily lives of these urban teenagers, and the importance of being identified by a tag or street name. Having a street name means ‘‘you're down'' with a gang, even if the gang is a group of friends or a fictitious one. Being a part of a collective had a cultural significance and the performance/assessment that began to emerge would build on this as an asset of the youths.

Another concern to emerge through these activities was the lot across the street from the shelter. This particular lot was abandoned and full of litter including such items as ripped open garbage bags, feces, broken bottles, and crack vials. A partially destroyed metal-link fence surrounded the lot with sharp fragments protruding in several places from a high-speed police chase. The damaged fence was both an eyesore and unsafe. We began to discuss ways as a community to address these concerns productively and worked with the teens to document the qualities of the lot, including its size, shape, and positive and negative attributes. Observations, mathematics, technology, and other skills were used to generate a reasonable list of things we could do to transform the lot into something that they and the community would enjoy. The teens generated many initial ideas including a basketball court, a garden, a playground, a stage, and a laser park. Next, they would need to engage in a refined scientific process whereby the plausibility of their ideas was defined in relation to their findings about the qualities of the lot. Entry 5 in *The Book* (December 14, 1998) shows the results of their assessment of the lot and includes information gained from discussions with landscape designers, gardeners, and other professionals who offered their assistance (Table 2).

Over the next 2 months, the teens did research to figure out what they might need to accomplish their options (e.g., whether the soil was viable for planting). They talked with landscape designers, gardeners, science teachers, and others to gain access to knowledge and resources necessary to enact their vision. They built two-dimensional (2D) and 3D models, and debated their ideas. As the photograph of the final 3D model shows (Figure 1), they settled on a community garden with beds for planting, a bird pond, and a stage because it would be beautiful, not too expensive, required minimal upkeep, and would support community interactions and activities. They also settled on a name for themselves and their work with the lot: Restoring Environments and Landscapes (REAL). The significance of this title cannot be understated.

First, as evident in various statements made by the youths, such ‘‘You down with REAL?'' or ‘‘I'm getting REAL painted on the back of my denim jacket,'' over time the project members formed their own gang with its own name (REAL), logo, and message. Furthermore, many of the youths proclaimed that the science they were doing was ‘‘real'' work, unlike the kinds of things

Table 2
Entry 5: Revised list of possibilities

Measurement team: We measured the cement block and it measured to 59 in. so there were 22 blocks and we got a measurement for the length and we did the same thing for the width but it had 19 blocks and we got the measurement. Then we added up all the sides for the perimeter then we times the length and width to get the area.

Initial List	We Learned That:
~~Basketball court~~	Already have one. Lot too small
~~Park~~	Already have a park
~~Football field~~	Lot too small
~~Baseball field~~	Lot too small
~~Archery range~~	No interest
~~Arcade for cyber games~~	Not everyone can use/community need
~~Swimming pool~~	Requires liability insurance
~~Dance club~~	Requires liability insurance, indoor structure
~~Laser challenge~~	Expensive, high maintenance

Remaining Possibilities
Playground
Garden
Little houses/club houses
50 cents or penny store
Jungle gym
Sandbox
Stage for shows

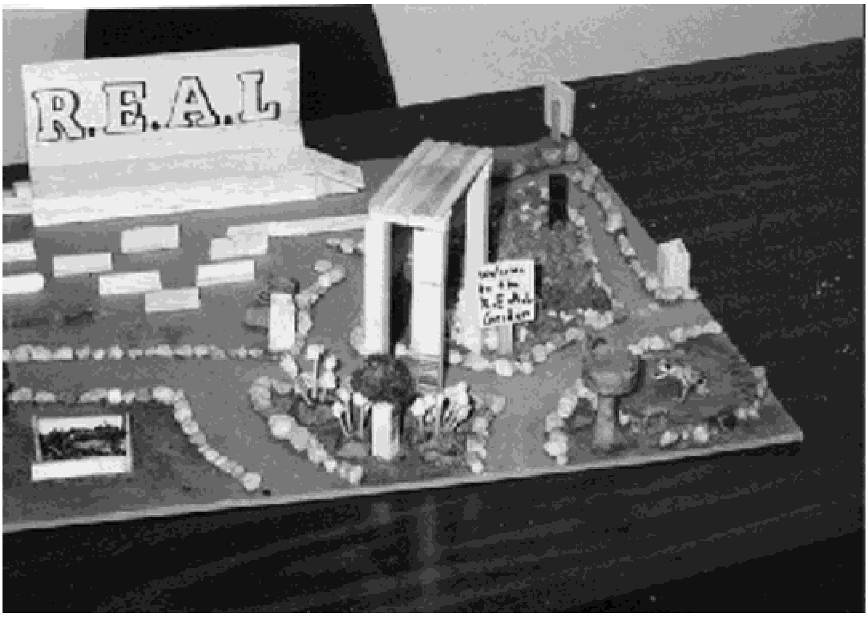

Figure 1. Photograph of 3D model of design (Entry 27).

they do in school and unlike the kinds of projects that kids with more resources might engage in. For example, in an interview, two of the involved youths stated that a suburb might ‘‘not allow a trashed abandoned lot to exist’’ and the ‘‘suburb would clean it up itself.’’ Even if suburban youths cleaned up a lot it would not be because they needed to in order to make their neighborhood better as was their own current circumstance; it would be because they were asked to join in a charitable activity.

The youths presented their plan to the local community, including individuals who lived in the shelter and in the neighboring apartments. They designed and printed notices for their meeting, set aside a room and time, and prepared presentations. One purpose of the meeting was to elicit feedback from those who lived in the area to ensure that they had thought through the important issues. Another important purpose was to enlist broad community support. Some of the planned activities, such as fixing the torn fence, would be difficult and would require additional volunteers to make them happen in a reasonable time frame.

After this meeting, the youths planned out specific activities to help them achieve their goal. They worked with Dana to locate and bring in volunteers to help them learn about landscaping, planting, building fences, and finding free resources within the city. They used their weekday get-togethers to revise plans and procure resources and necessary information. They also planned several Saturday community days for actual development of the lot. One of the youths involved in a video production about science and life in the inner city, Darkside, summarized much of the youths’ efforts in his narration of the final scene of the video. This final scene was filmed in the half-transformed lot, with Darkside, accompanied by two other youths, standing next to their REAL sign, with planting boxes behind them. He narrates:

> We try to build a lot for this community. We try to get more to help. We need more people to help for this community to build this lot. . . . We planted seeds over here in this box to make flowers that will be beautiful. We picked up the garbage and the trash. We fixed this fence here. We want to make the grass green, and make fruits and vegetables so that everyone will have enough to eat. And so that people will have a beautiful environment and see what we done for the community. We try to finish the garden to the best of our ability before the summertime comes. I did a lot. I helped mostly with the fence back here, and with planting this stuff, and with the clean up. So, I did a little bit, too. [Very forcefully and passionately, standing at the corner of the garden using his hands in the air for emphasis, he continues.] I put a little effort into it. We are going to have to change this garden to make it the best. We have to get a group of people to help us. Our group will do it. We will make a difference, make it better than before. We will make it into a beautiful community. A better community. A better environment, like it was before.
>
> (*The Urban Atmosphere*, 1999).

Performance/Assessment and The Book

Once the youths decided upon transforming the lot into a garden, we thought about creating specific task-oriented performance assessments to document what they learned about urban environmental science in general and the lot transformation in particular. After all, we wanted an authentic way to understand the youths’ engagement in science, their understandings of the nature and practice of science, and their own construction of scientific concepts in connection to their lived experiences. In fact, we engaged in some standard assessment activities such as interviews, group conversations, and reviews of student generated work to accomplish this task. For example, the culmination of the lot assessment was a series of maps and textual descriptions of the lot’s current status. Some of these were generated individually; some were generated in small groups. By reviewing the youths' maps and textual descriptions of the lot, we were able to determine who understood how to measure the lot and then transform these measurements into useful numbers such as perimeter and area. We developed a good sense of how well the youths were familiar with environmental science and botany by the language (and pictures) they used to describe the lot, the depth of the ideas they presented, the connections across ideas, and their modes of analysis. Did they simply state that they saw a broken bottle here and a newspaper there? Or did they describe the different kinds of pollution present and its impact on the various systems in the lot? After all, these were the kinds of things we talked about with the youths in their lot survey. How detailed where they in their descriptions? Did they include the plants, the makeup of the soil, the air quality, and the climate? Did they classify the things they found in the lot, and if so, how? Finally, we also got a sense of how well they were able to communicate their findings.

However, we quickly realized that these standard practices alone missed the essence of the kind of critical science in which the youths were engaging. It is not that we believed this information was not useful. In many ways it was essential in our decision-making process about how we might guide the youths in the next steps. We simply thought it was not a complete picture of what we needed to know—and what the youths needed to know—to push forward in meaningful and thoughtful ways. We wanted to create a performance assessment within the context of critical science education, and this implied expanding the definition of what was valued as knowledge and what would count as evidence, and who would have a say in such a process. It required a critical reflection of the purpose of assessment that emerged alongside the development of practice. It also implied expanding our vision of assessment and its link to our day-to-day work with the youths. Was the purpose of assessment to examine students' understanding of science? If so, whose science and what would count as science understanding, and how would we even know? These questions about science and assessment suggested to us that the method, and our search for that method, itself was performance/assessment.

The performance/assessment took the form of generating *The Book*, as it was referred to among the teens. For several weeks Dana had been keeping a collection of the work produced. During one session Dana introduced the idea of keeping track of "the things we do together." The young people suggested keeping a photo album, making a timeline, or "every time you guys come make a lesson plan . . . like school." The suggestion also emerged that the kids "jot down some things" at the end of a meeting or session. *The Book* was essentially a three-ring binder containing the material artifacts of the youths' efforts and included actual products (letters, notes, flyers, drawings, etc.), visual representations (photographs), direct inquiries (obtained through surveys, written evaluations/reflections, concept maps), and an attendance log and summary of activities (or lesson plans). At times, the products that became part of the history of the group were generated specifically for this purpose; for instance, someone would take notes during a presentation on community gardens so that we could remember what the presenter said. Other times, the products in the book were actual program activities, such as conceptual drawings of the design. Still other times, the artifacts in the book were responses or additions to already present items as the youth revised and refined their ideas. *The Book* was also shared with families and community members so that they could add their own ideas, experiences, and responses (in terms of the lot project, other concerns, or what was already present in *The Book*). In short, *The Book* was a jointly constructed process/document intended to reflect the collective history of the group as well as to represent how each member of the group developed in relation to the project.

Some might argue that the book is no different from the typical portfolio or even the typical lab notebook. We believe that there are key attributes to *The Book* which not only make it different from a standard portfolio and lab book, but which also reflect the critical science stance of responsive and emergent understanding, action, and change. First, *The Book* tells a public story of science for community change. This public story not only shows the science that was done, but also illustrates the gradual building of relationships, ideas, plans, strategies, revisions, and community, and how these changed over time. Both of these (the science and the context that influenced the science) play important roles in this performance/assessment. What is important here is how *The Book* allowed the values and cultural contexts that informed decisions about science, relationships, strategies, or anything else to be part of the public conversation. For example, reading through *The Book* helps one see how the inventions of a sandbox, playpen, and map of the garden emerged and reemerged in the ongoing dialogue and activity of design. The youths learned through participating in a design practice that included resources made available by the pro bono work of various professionals and community gardening organizations, science teachers, books, the Internet, and their community. All of these factors played an important role in what the youths decided and eventually accomplished, and thus all of these social and contextual factors play a role in the science story enacted by the youths.

Second, *The Book* was REAL (like the group's name) because it offered a recursive and dynamic picture of cultural shifts. In the documentation of our collective history, through conversations as well as actual artifacts, we are able to get a glimpse of a new sociology in the making. Identities of the youths were transformed from shelter boys and girls to a caring squad of environmental architects and leaders (the titles used over time to describe themselves and their work). *The Book* allowed the youth to represent their accomplishments and contributions in a dynamic fashion. It was also a tool that they used to display REAL to each other, their parents, and the broader community. Opening the story to multiple participants is critical because it forced the youths to enlarge their own science story. It forced them to consider other ideas, other experiences, and other worldviews in their enactment of science. Again, new inventions occurred because the youths revised their design plan for the lot to consider the needs of the larger community. This sort of ongoing documentation–reflection–action–documentation included within the book represents the transformation of the enactment of science when it is opened to multiple stories outside their close-knit community of the REAL group.

However, *The Book* does more than tell a story. Thus, third, *The Book* was a tool that itself allowed—indeed facilitated—the practice of community-based science with homeless youths to develop. Given the transient nature of their lives and the ongoing flux within the project, participants could enter and exit the history of REAL—a history that was made public and visible through the assessment or *The Book*. As a public demonstration of REAL's accomplishments, *The Book* often served as a catalyst for dialogue about the project both within and outside the group. *The Book* was accessible to all members of the community. It came with us on trips and on the subway; it was on interactive display during community events (that is, anyone could add to it); it was a mechanism for getting feedback and suggestions from participants and community members. Most assessments are conducted under the premise that the findings will help improve programs and instruction. Here, the value of the methodology was evidenced not only in the usefulness of its findings (i.e., the content of *The Book* and its interpretation), but also in the use of the tool itself. In the simultaneous development of practice and assessment, a methodology emerged in relation to the specific interests, concerns, relationships, and practices of a particular group of people. This positions assessment as both a method and an ongoing search for method. As Holzman (1997) described it, "practicing method is an explicitly participatory activity that entails the continuous, self-conscious deconstruction of the hierarchical arrangements of learning, teaching, and knowing" (p. 11). Thus, documenting the process by which we progressed as a group, the things we accomplished and learned along the way, and the performances which young people developed allowed a teaching/assessment methodology to emerge that empowered the youth to represent their achievements, and allowed those representations to form the basis for next steps.

Such a different approach to performance assessment as a book provides different kinds of insights into the youth with whom we worked. For example, from a reform-based stance, it can be argued that we learned a great deal about the kinds of conceptual understandings youths held about what and how plants grow, about urban pollution, about science process skills such as mapping, computation, measurement, observation, and analysis, and about the communication of results (see Fusco, 1999, for a more detailed discussion). In fact, many of the activities the young people engaged in are consistent with performance standards for middle school science (New Standards, 1997). For instance, students might evidence an understanding of scientific thinking by ‘‘evaluating the claims and potential risks and benefits of a newly advertised diet pill’’ (New Standards, 1997) or by evaluating the characteristics of an urban physical space to determine the viability of ideas, considering the risks and benefits to the public (REAL).

However, *The Book* also enabled us to learn more about the value-laden nature of science, the ways in which science is shaped by context and broadened through multiple worldviews, and how youth underwent cultural shifts in such areas as identity (from shelter youth to caring squad) and in the production of science (from fake school projects to real social action). It also enabled us (youth and adults) to understand what it means to be responsive to the moment-by-moment shifts in both our production of science (and what we did with the lot) and in our presentation of that science (with the larger community through public conversation and debate, the kinds of things selected to go into the book, and through group-based conversations about what ought to happen and what it meant when certain things did happen). It also enabled us to see how an assessment such as *The Book* could document our process and inform our process (see Fusco, 1999, for a more detailed discussion).

Looking Ahead: Implications for Assessment and School Science

What this practice raises are vital questions about the conditions required to create a radically inclusive and transformatory practice of science and science assessment. For one, the nature of science and knowing in science were supported by authentic and meaningful practice. The teens were active producers of a science that made sense to them, served a communal purpose and was linked to social use, and drew upon their strengths. Science and science ideas emerged from having this purpose and real-world obligation. Here, science was supported by a non-Western vision; it was socially oriented rather than task oriented (McShane & Yager, 1996). The assessment both helped to create this emergent practice and document it, and was also socially oriented and real. It did not encompass separate objective tasks constructed to measure disparate knowledge and skills, although we considered this possibility. Rather, *The Book* was inclusive of the totality of REAL’s achievements, a product they were proud to use to represent their accomplishments. The enactment of science was situated holistically and historically and was representative of students’ worldviews by virtue of their participation in both the creation of REAL and the book.

Although the work occurred in an after-school context, we see implications for the classroom. For one, positioning the nature of knowing in science as a human-made explanation of the world opens up the possibility of expanding the definition of science and how and whose scientific concepts and practices count. It affords opportunities to include multiple worldviews in what counts as knowing in science. We see this expansion as particularly possible when science is connected to real students and society, when the enactment of science occurs in response to local needs. Connecting school to community and society, although new to science education, has a long history, as evident in such practices as experiential education, community education, service learning, action research, and many youth development efforts. Because such practices are often more interdisciplinary than traditional school science, more recently science educators are examining ways that such practices meet standards in school science (e.g., Fusco, 2000; Rahm, 1999). This article advances such work by linking the production of community science to the production of assessment in science.

Critical science supports a pedagogical position that views student achievements in the cultural and historical context of the domain, the classroom, the community, and people's lives. Assessments based on science as truth, even in the broadest sense, exaggerate the nature of science and what it means to know and do science, leaving many students alienated from science. Science emerges from, and thereby reflects, the values and beliefs of those who create it and is situated within a continuous process of changing contexts and changing ideas. Furthermore, in instrumental ways, reformers have helped us see how assessments based on individual achievements of mastery and recall of discrete facts distort the socially constructed nature of scientific ideas and practice of science, even in the classroom. The progression of science occurs and relies on a community of practitioners. Individual advancement within that community rests on that community. Work collectively produced should be understood in relation to what and how the group produced it. As Roth (1998) stated,

> The processes by means of which students accomplish their tasks, the decisions they make, the material problems which they construct and resolve, the rocky aspects of their relationships which they learn to deal with, the interactions and help they provide to other students, all have disappeared, become invisible in, and unrepresented by, the actual piece handed in for evaluation (p. 285).

Assessments that represent knowledge as a final product present a one-sided view to students (and teachers) and do not account for science or science learning as a recursive process.

Science classrooms are being transformed into scientific communities where students collectively muddle in ill-defined problem frames, such as engineering (Roth, 1998), technology (McShane & Yager, 1996), and ecological research (Eisenhart, Finkel, & Marion, 1996), to name a few. In such environments where learning is a dynamic continuous process, members of the group have many opportunities to play with concepts as they reemerge in different contexts. This sociocultural account of learning has rendered previous cognitive accounts as insufficient for understanding the dynamic, recursive process of learning as socially and culturally based (Rogoff & Chavajay, 1995). That is, individual contributions to a collective product are difficult to isolate. If communities of expert practice are to be replicated in the classroom, the assessment process will need to situate the learning process more closely in the development of the group. In REAL history, new inventions did not replace old ones but offered the occasion for old ideas to be reinvested in new ways. Here, the documentation of our collective history captured the spiral nature of how knowledge emerged and reemerged, or was evident in many contexts. The assessment, like science, can be viewed as an ongoing, emergent process that serves to inform teachers and students of their individual and collective growth within their community and transforms—at every moment and every level—the very nature of scientific practice by recognition (and practice) of its embedded nature. In other words, if the assessment can be constructed as an ongoing tool for individual and collective learning and development that cuts across conceptual understandings and their foundational ideologies, how might the assessment also be used to challenge, transform, and ultimately move forward the practice of the individual and the community? What we see as important here are the intersections of knowledge-made-public, and the social, cultural, and historical bases for such public knowledge production.

For us, this kind of thinking raised the following questions and issues (Table 1): How might assessment be reframed so that it serves to make public an individual's (or group's) understandings, as well as the social, cultural, and historical bases for such knowledge production? How can the public nature of these understandings and experiences be used as a tool for transforming science, scientific practice, and self within local communities such as classrooms? Finally, how might assessment push the goals and purposes of science from mastery of content to students as active users and producers of science, where scientific concepts and practices emerge from dealing with societal problems/real life and the needs of the local community? In other words, in what ways can performance assessment emerge from individual and collective responses to local concerns? How can such responses be both the production of science and the production of assessment? These questions are important because they suggest that performance assessment provides an excellent resource to help create a participatory and inclusive practice of science that draw more closely and critically from the culture and practices of young people.

If the teaching and learning of science are culturally and historically contextual and involve the dynamic and reflexive interactions among teachers, students, science, and society, assessments also ought to be viewed as an embedded, dynamic, and recursive process that raises understandings of issues of access, enactment, and the critical analyses of both. We see the embedded, recursive, and dynamic elements of performance assessment as consequential in three particular ways. First, the fundamental goals of assessment must broaden to include action and change within the process of determining what students know and understand; that is, learning is not just an academic and cognitive task, it is about interacting with/in the world. Performance assessment activities can draw students' worldviews into the doing of science in ways that both transform science and challenge their worldviews and allow these realities to become more available to science teachers. This relates to the second point: Performance assessments ought to be emergent activities closely tied to responses to local (individual and collective) concerns, needs, and problems. Such responses ought to be both the production of science and the production of assessment. Third, science is a participatory activity with shifting goals based on growing and changing understanding as well as changing participants. For performance assessment to be responsive to such a reality, including the realities of the lives of the children involved, performance assessment must be part method and part search for method. This breaks away from the traditional—and even progressive—linear model where, after the assessment, new material is taught and the process begins again. Rather, in an ongoing search for method, tools are continuously created in relation to ongoing changes in the group, goals, activities, interests, and outcomes. This is particularly important in terms of both issues of equity and diversity where multiple and emergent perspectives help shape the use and production of science in classroom contexts.

In summary, a critical science education perspective opens the boundaries of what is included as science and the assessment of science. It reflects the paradigm shift that relates to teachers as thinkers rather than transmitters of knowledge and relates to students as active agents in using and producing knowledge. It demands that we create new tools for teaching science and representing student achievements in science that are inclusive, authentic, globally responsible, and emergent, and dynamically create and reflect the collective process of creating culture and history.

References

American Association for the Advancement of Science. (1993). Benchmarks for science literacy. New York: Oxford University Press.

Atwater, M. (1996). Social constructivism: Infusion into the multicultural science education research agenda. Journal of Research in Science Teaching, 33, 821–838.

Barton, A.C. (1998). Feminist science education. New York: Teachers College Press.

Barton, A.C., & Osborne, M. (2000). Building inclusive science through oral histories. Women's Studies Quarterly, 28, 271–295.

Brickhouse, N. (1994). Bringing in the outsiders: Reshaping the sciences of the future. Curriculum Studies, 26, 401–416.

Cohen, C. (1996). New ways of making babies. Bloomington, IN: Indiana University Press.

Eisenhart, M., Finkel, E., & Marion, S.F. (1996). Creating the conditions for scientific literacy: A re-examination. American Educational Research Journal, 33, 261–295.

Epstein, S. (1997). Impure science. Berkley, CA: University of California Press.

Fusco, D. (1999). Assessing science in and out of school. Technical Report to the National Science Foundation (EHR, 9733700). New York: Teachers College, Columbia University.

Fusco, D. (2000, April). Building an inclusive and relevant science through community gardening. Paper presented at the American Educational Research Association, New Orleans, LA.

Gill, D., & Levidow, L. (1989). Science curriculum innovation and Holland Park School. In D. Gill & L. Levidow (Eds.), Anti-racist science teaching (pp. 147–174). London: Free Association.

Gipps, C. (1999). Socio-cultural aspects of assessment. In A. Iran-Nejad & P.D. Pearson (Eds.), Review of research in education (vol. 24, pp. 355–392). Washington, DC: American Educational Research Association.

Gitomer, D.H., & Duschl, R.A. (1995). Moving toward a portfolio culture in science education. Technical report. Center for Performance Assessment. Princeton, NJ: Educational Testing Service.

Harding, S. (1998). Is science multicultural? Postcolonialisms, feminisms, and epistemologies. Bloomington, IN: Indiana University Press.

Holzman, L. (1997). Schools for growth: Radical alternatives to current educational models. Mahwah, NJ: Erlbaum.

Keller, E. (1985). Reflections on gender and science. New Haven, CT: Yale University Press.

Kulm, G., & Stuessy, C. (1991). Assessment in science and mathematics education reform. In G. Kulm & S.M. Malcom (Eds.), Science assessment in the service of reform (pp. 71–88). Washington, DC: American Association for the Advancement of Science.

Lave, J. (1988). Cognition in practice: Mind, mathematics, and culture in everyday life. Cambridge, UK: Cambridge University Press.

Lee, O., & Fradd, S.H. (1998). Science for all, including students from non-English-language backgrounds. Educational Researcher, 27, 12–21.

McGinn, M.K., & Roth, W.M. (1999). Preparing students for competent scientific practice: Implications of recent research in science and technology studies. Educational Researcher, 28, 14–24.

McShane, J.B., & Yager, R.E. (1996). Advantages of STS for minority students. In R.E. Yager (Ed.), Science/technology/society as reform in science education (pp. 131–138). New York: State University of New York Press.

New Standards. (1997). Performance standards: Middle school (vol. 2). National Center on Education and the Economy, University of Pittsburgh.

National Research Council. (1996). National Science Education Standards. Washington, DC: National Academy Press.

Rahm, J. (1999, April). Is that really science? A look at the science practice of an inner-city youth gardening program? Paper presented at the annual meeting of the American Educational Research Association, Montreal, Canada.

Rodriguez, A.J. (1998). Strategies for counterresistance: Toward sociotransformative constructivism and learning to teach science for diversity and for understanding. Journal of Research in Science Teaching, 35, 589–622.

Rogoff, B. (1990). Apprenticeship in thinking. New York: Cambridge University Press.

Rogoff, B., & Chavajay, P. (1995). What's become of research on the cultural basis of cognitive development? American Psychologist, 50, 859–877.

Roth, W.M. (1998). Designing communities. Boston, MA: Kluwer Academic.

Roth, W.M., & McGinn, M.K. (1998). UnDELETE science education: Lives/work/voices. Journal of Research in Science Teaching, 35, 399–421.

Roychoudhury, A., Tippins, D., & Nichols, S. (1995). Gender-inclusive science teaching: A feminist perspective. Journal of Research in Science Teaching, 32, 897–930.

Sfard, A. (1998). On two metaphors for learning and the dangers of choosing just one. Educational Researcher, 27, 4–13.

The Urban Atmosphere. [Film]. Available from the Urban Science Education with Integrated Technologies Project, The University of Texas at Austin, 340 Sanchez Building, Austin, TX, 78712.

Wolf, D., Bixby, J., Glenn, J. III, & Gardner, H. (1991). To use their minds well: Investigating new forms of student assessment. Review of Research in Education, 17, 31–74.

Young, R. (1989). Racist society, racist science. In D. Gill and L. Levidow (Eds.), Anti-racist science teaching (pp. 16–42). London: Free Association.