
James Buchanan Cooper, Jr.

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Approved by
Advisor: Dr. George W. Noblit
Reader: Dr. Eileen C. Parsons
Reader: Dr. Deborah Eaker-Rich
Abstract
(Under the direction of George Noblit)

Science education researchers have attempted descriptions of the relationship between science studies and science education. Such descriptions have applied the aggregate logic of literature reviews to the interpretive works of sociologists and anthropologists. Meta-ethnography (Noblit & Hare, 1988) provides a framework for the synthesis of interpretive studies which may be more appropriate to describing the relationship between science education and science and technology studies. This project attempts to articulate that relationship further using Latour and Woolgar’s Laboratory Life, a seminal work in science studies, and Barton’s Teaching Science For Social Justice, a study of the scientific practice of youth who live in homeless shelters. The meta-ethnographic synthesis reveals that the relationship between the two communities of scientific practice and the knowledge they use and produce does much to determine the form of that practice.
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Introduction

Two Related Notions of Authenticity in Science Education

Science educators and science education researchers are faced with the dual task of finding a way to make science instruction accurate and inclusive. Both the accuracy and inclusiveness of such instruction can be viewed in terms of its authenticity. Recent science reform documents advocating the opportunity for all students to attain a high level of scientific literacy call for a combination of classroom experience similar to the work of professional scientists and the simultaneous provision of activity that it meaningful for all student. The National Science Education Standards (1996) describe “inquiry into authentic questions generated from student experiences” as “the central strategy for teaching science.” (p. 31) Inquiry has a two-fold definition, one which is comprised of the ways in which scientists study the world and provide evidence-based explanations of their findings. For students, inquiry is a set of activities through which they learn both “scientific ideas,” and “how scientists study the natural world.” (p. 23) The distinction between scientists and students is later collapsed as inquiry is redefined as “a set of interrelated processes by which scientists and students acquire knowledge and develop a rich understanding of concepts, principles, models and theories.” (p. 214) Thus, the initial juxtaposition of scientists and students implies a comparison between the activities of the two while the later collapsed definition makes possible a two-fold concept of authenticity in science education. First, the questions on which those inquiry processes are focused ought to be authentic inasmuch as they are derivative of student interests, knowledge and skills. Second, as defined by the
Standards, inquiry implies that the processes students use to acquire knowledge and conceptual understanding ought to be authentic inasmuch as they are processes shared with professional scientists.

Other science education reform advocates (Roth and Barton, 2004) have described a vision of scientific literacy for school students that would allow them to be intelligent consumers of the products of professional science and allow them to be capable of engaging in informed and intelligent discourse related to scientific issues of particular global and local importance such as water quality and the fate of the urban environment. This form of scientific literacy implies a synthesis of science learning that is authentic in both of the ways described above. The inquiry learning that takes place in science classrooms should lead to scientific literacy that reflects back on the student backgrounds from which its authentic questions were to have been drawn. Students who learn to practice science in this way will have constructed an understanding of the relationship between their lives in their local communities and science as it is practiced by professionals both in laboratories and the field.

Social Studies of Science as a view into the Authentic Practice of Scientists

Over the course of the last three decades, numerous scholars have engaged in research informed by the philosophy, history and sociology of science, collectively considered to be either science studies or science and technology studies. For purposes of this work, the term science studies will be used in order avoid confusion with the Science-Technology-Society reform of the 1980s and 1990s. Science studies has emerged as its own sub-discipline within each of the three more traditional subject areas of history, philosophy and sociology. The history and philosophy of science have longstanding relationships with science education, for example the influence of Kuhn’s (1996) paradigm shift on the development of a conceptual
change theory of science learning (Posner and Strike, 1982) as well as in its ongoing consideration of the nature of science (Eflin, Glennan, & Reisch, 1999; Smith and Scharmann, 1999). The work of historians and philosophers of science is accurately categorized as focusing on an idealized, clean version of scientific practice that is not focused on the day-to-day work that takes place in laboratories and the field (Roth, 1998).

The relationship between science education and the sociology of science, particularly its ethnographic examinations of communities of science (Latour and Woolgar, 1986; Traweek, 1988) is less thoroughly expressed and holds a good deal of potential for additional exploration. Studies from this field present interpretive accounts of the life of the laboratory in all of its idiosyncratic messiness. Perhaps this is, in part, the image of science that inquiry learning hopes to make more common in classrooms but which science educators have begun to contemplate only in the last decade. It offers authentic, interpretive images of the practice of professional scientists.

Articulations Already Made Between Science Studies and Science Education

Much of the work that has sought to link science studies and science education has taken the form of reviews of science studies literature and its implications for the practice of science in classrooms. It addresses how the images provided by science studies might make the practice of classroom science more similar to that of professional scientists as well as how science educators can use its research methods in their own field. An entire issue of Research in Science Education was devoted to an exploration of that link. There, two of the nine articles were reviews of the literature with implications for practice and methodological considerations in science education research. (Costa, Hughes & Pinch, 1998; Chen and Crawford, 1998). Several authors applied theoretical frames derived from science studies
research to work in science education ranging from the construction of science by guidance counselors (Larochelle & Desautels, 1998) to a consideration of Latour’s (1987) actor-network theory as an analytical lens for course construction (Gaskell & Hepburn, 1998).

Similarly, Roth and McGinn (1997, 1998) identify science and technology studies as a potential partner in a cross-disciplinary collaboration with science education. Science educators could draw on science and technology studies in four main ways. First, works from science studies could be used to teach students a more accurate image of the nature of science and scientific practice. Second, science studies have revealed the central importance of visual representations or inscriptions in the practice of professional scientists. The previously described insight is a potential boon to those science educators charged with designing curricula or learning environments. Science studies also utilize an array of research methods to examine the work of scientists which science education researchers might consider applying to the examination of science learning. Finally, science studies illuminate the relationship between a range of research reporting techniques and the theories that undergird them, a possible avenue for expanding the ways in which science learners might consider and report their own research. While these insights might improve classroom practice by advancing authenticity associated with the imitation of the practice of professional scientists, they fail to address the question of improving the access of all students to a meaningful practice of science, the form of authenticity explicitly invoked in the National Science Education Standards (1996).

Cunningham and Helms (1998) specifically identify the sociology of science as a tool for the reconceptualization of school science content and pedagogy with greater accuracy in expressing the work of professional scientists as a collaborative, democratic
enterprise. Such a reconceptualization would serve as a "tool for making science education more authentic and more inclusive." It would allow teachers to put a more human face on the practice of science by professionals, minimizing the portrayal of science as being strictly a very competitive, highly technical endeavor practiced by intelligent but detached white males with advanced degrees, far removed from the everyday lives of students' communities. Such science pedagogy would emphasize the importance of interaction among experimenters through the pooling and evaluation of data or the subdivision of a particular experimental task into units designed for completion by a small group. Small group work would also facilitate the integration of "cooperative competition" among professional practitioners of science as students might work separately to find a best solution to a particular problem.

Insights from the sociology of science also raise questions about the sources of authority in classroom science (Cunningham and Helms, 1998). The twin sources of authority and guidance in school science classrooms are typically teachers and textbooks. A practice of science informed by sociology of science could deemphasize the authority of those sources, instead providing students with images of scientists who validate their work by informing other scientists, raising and discussing questions and difficulties. Students might also consult with popular science publications which would serve as a surrogate to the refereed journals used by professionals. Diminishing the authority of the teacher and text opens the possibility of more peer review of evidence and argument among students themselves.

However, drawing on work done in science studies runs the risk of limiting the work of science educators to mimesis, particularly if the interdisciplinary connections made between the two fields is done primarily through literature reviews followed by suggested
classroom applications. This narrows both the focus of the classroom practice of inquiry processes and its greater goal, scientific literacy. The science classroom risks becoming merely a training ground for future science professionals who enter the profession with a clearer picture of the work that will occupy them for the duration of their careers. This poses a serious problem for students who are not served well by school science as it is currently conceptualized, particularly since competence at school related tasks bears little or no relation to how competent one is in everyday situations (Roth and Barton, 2002). To describe science learning as authentic has often meant to engage in work similar to that done by professional scientists in their laboratories. Indeed, science studies have been criticized for a lack of focus on field research such as environmental biology (Bowen and Roth, 2000). However, if authenticity in science learning is also conceptualized in terms of how inquiry driven questions bear on students' everyday activities and community context, then the connection between science studies and the work of science educators needs to be articulated across a broader range of studies.

Many of the descriptions of the potential relationship between science studies and science education (Roth and McGinn, 1998,1999; Cunningham and Helms, 1998) are quite general in their review of the science studies literature. Time and again, Latour and Woolgar's *Laboratory Life* (1986) is cited, described as a seminal work in the field and held up as an influential portrait of the work of laboratory scientists. It would be useful to consider *Laboratory Life* more closely. In combination with a critical ethnography of a practice of science, a work such as *Laboratory Life* taken from the sociology of science could serve to further humanize the professional practice of science, perhaps providing a glimpse of two messy practices of science through two diverse interpretive lenses.
Such an endeavor is in part a response to two trends in previous research. First, the relationship articulated between science studies and science education has been almost exclusive in its focus on classroom science as the context for science learning. This is ironic in light of the fact that some of the advocates of forging such a relationship also advocate a broadening of the idea of scientific literacy. Roth, McGinn & Bowen (1999) draw on Lave's (1988) work related to situated cognition and legitimate peripheral participation. The notion of legitimate peripheral participation in science education fits comfortably with science studies, as students' engagement with scientific experts as peripheral participants would likely have to occur outside of the classroom, yet the focus of most of the research linking the two fields and applying legitimate peripheral participation have only done so in the context of changing classroom practice. Yet there is a body of critical ethnographic work that describes and interprets practices of science outside of school, in communities and among children for whom science reform efforts are especially relevant. Barton (2003) describes the practices of science constructed by groups of children living in homeless shelters in two different parts of the U.S. in Teaching Science For Social Justice. This work focuses on how and why these children construct a practice of science for themselves outside the context of school, yet it also has implications for the reform of science instruction in schools.

Second, the explication of the body of science studies research applicable to science education has generally taken the form of literature reviews and recommendations for practice or the importation of a theoretical frame or method from science studies into science education. The first approach does a disservice to the particularities of individual studies from science studies by applying a positivistic logic to their interpretivism. While generalizations about what science studies have to offer science educators have been show to
be useful for designing experimental classroom practices in limited cases (Roth, McGinn & Bowen, 1996) and framing reform efforts in different terms (Cunningham and Helms, 1998) they buy into a logic that reduces the inherent complexity of interpretive research to something that can be aggregated and used as a basis for generalization. Another method of relating the two fields is possible. Rather than relying on a review of the literature as a source of generalizations or applying a frame from one field to research in the other, meta-ethnography (Noblit and Hare, 1998) retains the interpretive focus of the endeavor while also creating a reciprocal relationship between works from both fields.

**An Interpretive Synthesis Method for Interpretive Studies**

Noblit and Hare (1988) propose meta-ethnography as an "approach to synthesizing understanding from ethnographic accounts" (p. 10). Eschewing the aggregative logic of traditional literature reviews and meta-analyses, meta-ethnography provides an explicitly interpretive manner in which to reveal analogies between ethnographic accounts, reducing the accounts through the selection of the key metaphors or organizers used by the authors. The senses of those reduced accounts are then translated into one another. Whatever analogies the translations make clear then form the meta-ethnographic synthesis. Studies synthesized using meta-ethnography are generally focused on a similar topic. In this case, the two studies being synthesized both portray and examine images of people practicing science. A typical literature review might privilege either critical ethnography or science studies by creating an aggregate sense of the relevant work in the field, then using that sense as a springboard for commentary on the other field. We would learn only what science studies have to say to critical ethnographers in science education or what critical ethnographers have to say to those working in science studies.
Because a meta-ethnography can take the form of a reciprocal translation of the two studies into one another, it might reveal what works from both traditions have to say to one another as well as producing a synthetic statement of the senses of the two works in combination. It is also possible that the metaphors used in one of the two reduced accounts might better convey the sense of both of the accounts. A meta-ethnography is emergent inasmuch as the translations of studies into one another is accomplished via a "search for adequate metaphors to express the studies and their relationships" (Noblit and Hare, 1988, p. 35).

Meta-ethnography was originally conceived not as a way to consider synthesis, but interpretation (Thorne, S., Jensen, L., Kearney, M.H., Noblit, G., & Sandelowski, M., 2003). It emerged from a theory of interpretation as translation, the idea that ethnography amounts to a metaphorical analogy which the ethnographer makes explicit. This becomes necessary when ethnographers encounter a situation in which the community in which they are working engage in a different practice from one they might expect in a given situation; at that point, a comparison/translation into the ethnographer's terms of understanding is necessary so that the practice might make sense. Those translations amount to a statement of how a particular practice relates to a practice known to the ethnographer. In the case of a meta-ethnography, two or more sets of metaphorical translations are evaluated and translated into one another at a level of understanding which seems twice removed from the observation of practices accomplished by each ethnographer in her/his original study.

This poses a particular set of problems for meta-ethnographies like the one attempted here, which are aimed at professional practitioners in a particular field. It requires a consideration both of the knowledge being synthesized and the audience to whom the
synthesis is addressed (Thorne et al., 2003). One part of this consideration bears on how the knowledge being synthesized is situated both with respect to the present and the original context in which the study from which it was drawn. This is a question of the degree to which the experience from which the knowledge was drawn remains pertinent to the present day or how repeatable the history it interprets might be. The second question in considering a meta-ethnography intended to influence professional practice is whether the expressed synthesis of studies has meaning to both practitioners and those people whose lives they affect.

In this case it is important to consider how the homeless children, or disenfranchised children in general might be able to use the knowledge provided by a meta-ethnography. The goal of this particular meta-ethnography is to take the work done in previous literature reviews and research connecting science studies to science education in a new direction. First, a meta-ethnography focuses the scope of the endeavor to reduced accounts from qualitative studies. It makes possible a more rigorous explanation of the relationship between science studies and science education so that rather than speaking in vague terms about what might be taken from science studies and applied to classroom teaching of science, researchers are able to make concrete connections between particular interpretive accounts taken from the two fields. This would amount to making specific links between works from the fields science studies and science education instead of merely making the blanket claim and extrapolating suggestions for practitioners of science education research and science educators from it.

The remainder of this thesis is devoted to an attempt at constructing a meta-ethnographic synthesis of Laboratory Life and Teaching Science For Social Justice. First, the
organizing metaphors from each work are described and evaluated using Noblit and Hare’s (1989) criteria for metaphors in a qualitative study. Because the metaphors used in both works are a part of each study’s broader conceptualization of a practice of science, this evaluation of metaphors also elaborates on those conceptualizations. After evaluating the metaphors, their relationship across the two studies is described and a meta-ethnographic synthesis of the sense of the studies is attempted. Here, Kuhn’s (1989) concepts of normal scientific research and the eventual necessity of a paradigm shift is useful as a frame through which to view the specific differences in the two practices of science. Finally, the issue of authenticity is revisited through the new lens provided by the synthesis and implications for further research are explored.

A. Selection and Evaluation of Organizing Metaphors

Constructing a meta-ethnography begins with a focus on the "concepts, themes, organizers, and/or metaphors that the authors employ to explain what is taking place" (Noblit and Hare, 1989, p. 39). In the case of the two studies in question, these metaphors are related to each author's description of how science is practiced. There are four criteria for the metaphors used in a qualitative study: economy, cogency, range and apparenty (Brown, 1977, and Martin, 1975 as cited in Noblit and Hare, 1989). Economy refers to whether a metaphor is the simplest concept that accounts for the phenomena and is easily represented and manipulated. Cogency describes a metaphor's ability to explain phenomena without "redundancy, ambiguity, and contradiction" (p. 34). Range refers to the power of a metaphor to incorporate other symbolic domains. Apparenty accounts for the ability of a metaphor to show rather than refer to observed experience. Each of the metaphors used in both Laboratory Life and Teaching Science For Social Justice must be considered in light of these
criteria for adequacy.

Latour and Woolgar (1986) used six main concepts to argue that "scientific activity comprises the construction and sustenance of fictional accounts which are sometimes transformed into stabilised objects" (p. 243). For purposes of this study, these six concepts will be taken to be the central metaphors around which their interpretation of their laboratory observations revolved. The phrase, scientific activity, is taken to be analogous in sense to children's practice of science. The six main concepts are construction, agonistic, materialization/reification, credibility, circumstances and noise. The work of the laboratory is the construction of scientific fact which is stripped of all evidence of its construction; in the agonistic field successful persuasion of the reality of a scientific fact results in the belief that one has not been convinced at all; materialization results in the belief that material considerations were minor components of thought processes necessary to create the scientific fact, investments of credibility allow scientific fact creators to claim that the fruits of their labor are in no way connected to economics or beliefs, circumstances of fact construction are eliminated from accounts. The thrust of all of this is that the successfully constructed and accepted scientific fact stands alone, as a thing apart from the very world out of which it was created. It is made manifest in new forms of laboratory equipment and reified in the form of citations in publications which follow from it, though eventually a successfully constructed scientific fact requires no citation because all traces of authorship have been eliminated.

The ability to describe the metaphors in the manner above attests to their economy and cogency. Latour and Woolgar (1986) very clearly have an integrated scheme which accounts for and gives some meaning to the phenomena they observed. The incorporation of the economic notion of credit/credibility is particularly noteworthy for its range. All of the
metaphors appear to fulfill the requirement of apparency, though the experiences as they are show in *Laboratory Life* are interpreted in a manner that serves to undermine the mystique of science as it is practiced in the laboratory, something for which Latour and Woolgar have been criticized (Slezak, 1994b).

Barton (2003) describes "a practice of science" (p. 36) to suggest "a vision of science education for which we might strive if we are to refocus our efforts in understanding youth lives and youth engagement with science" (p. 34). It allows for a focus on how and why urban youth engage in science across domains in their lives, a way to make sense of how and why that engagement changes and it deemphasizes "what youth know and can do" (p. 34) instead emphasizing "how youth use what they know and can do to act on and within the various domains that make up their lives" (p. 34) in order to understand the forms, importance and uses of science in youth lives. This practice of science draws on critical literacy studies, social studies of science and situated cognition.

Barton (2003) criticizes current science literacy and reform efforts for their failure to address the science education requirements of youth "whose uses for and production of science might be vastly different from our own or from those documented and described in policy initiatives and national frameworks" (p. 35). By critically reshaping the nature of science to fit the lives of the children she studies in *Teaching Science for Social Justice*, Barton is giving the compelling arguments made in science studies short shrift. She is focused on the authentic, here meant as student and context specific, questions on which inquiry science learning focuses, while neglecting the possibility that the work in which the children participate might also be richly authentic in its similarity to the practice of professional scientists. Using meta-ethnography as a framework for synthesis, this study will
attempt to show that social studies of science and the practice of science Barton frames are more commensurable than she has allowed by extending her argument to include this second form of authenticity.

Latour and Woolgar's (1986) study reflects on a practice of science that might be considered normal science, the explication and extension of a paradigm (Kuhn, 1996). It lacks a critical agenda, save for the determination that science might be considered to be a human construction rather than the reading of the book of nature. Barton's (2003) work is at once a critique of school science and an attempt to integrate social studies of science with critical literacy studies and situated cognition. In using the framework of a practice of science she appears to indicate that the same framework could be applied to anyone doing science in any context, though in the case of her study the purposes of youth’s practice of science are particular to their life circumstances. For this reason, Barton's explication of practice is somewhat problematic. For the students she worked with, the construction of a practice of science was not one that had a set definition of practice or of science. Rather, the practice of science is a metaphor for what students believe science to be, why they participate in "science events" (p. 36), how the youth participate in science and what meaning they bring to the actions in which they engage in doing science. For Barton's students, the practice of science is framed as a way into authorship despite their minimal or non-participation in the traditionally conceived vehicle for admission into a community of scientific practice, the science classroom.

The key organizers in Barton’s (2003) account of a practice of science do not constitute the practice itself. Instead, they describe “the terrain that allows their practices to grow and thrive” (p. 43). This helps to illuminate their adequacy with respect to range and
apparency. Because they establish “terrain”, Barton’s organizers describe youth’s practice of science in terms that both incorporate other symbolic domains and by doing so “use language to show rather than refer to experience” (Noblit and Hare, 1988, p. 34). There are no clear problems with the cogency of Barton’s key organizers, as they are all easily integrated into the account. However, their economy is debatable. This is particularly true of “power and co-opting science spaces” (p.67) and “relevant science: activating resources in non-standard ways” (p. 103). Both of these organizing metaphors are two-fold yet are capable of forming four organizing metaphors sufficiently complex to stand alone. The argument for maintaining the structure Barton uses might be that both metaphors consist of ends (power and relevant science) and means to those ends (co-opting science spaces and activating resources in non-standard ways). The incorporation of means and ends in single organizing metaphors points to the fact that these might not be the simplest concepts to account for the phenomena (Noblit and Hare, 1988).

**B. Points of Intersection Between The Two Studies**

Latour and Woolgar's (1986) study focused on the work of scientists in an endocrinology lab as they establish the existence, structure and function of Thyrotropin Releasing Factor (Hormone). They interpret the work of the scientists as "the construction of scientific facts" via a "process of literary inscription" (p. 45). This "process of literary inscription" (p. 45) produces "statements" (p. 236) which take the form of papers and journal articles as well as conversations among scientists in the laboratory itself. Those statements are posited in an "agonistic field," (p. 237) where they are operated upon. There, scientists add and subtract "modalities" (p. 77) to the statements which affirm or deny their relative validity among competing statements. A statement that has no modalities is considered to be
an undisputed scientific fact. Those facts are assembled in an effort to construct reality, which Latour and Woolgar argue is a consequence of dispute settlement rather than being its cause. That is, when scientists stop arguing, reality can be said to have some sort of agreed upon existence among them. This stands in opposition to a notion of scientists working to uncover or discover a preexisting reality, which when discovered will silence the arguments of critics. Once a statement moves out of the agonistic field, it may take the shape of an object or apparatus via "materialization/reification," (p. 238) the incorporation of intellectual components/statements into such an apparatus. Scientists gain "credibility" (p. 194) via "cycles of credit," (p. 192) both economically and socially. Credibility is gained through the successful work of literary inscription, then reinvested to obtain new, better inscription devices to produce more inscriptions, statements and articles in order to advance scientists' individual careers. The work that scientists do and its products are "entirely fabricated out of circumstance" (p. 239) which take the form of "networks" (p. 183) or "positions" (p. 210) depending on the perspective of the observer.

The youth in Barton's (2003) study construct a practice of science in order to negotiate power relationships. By "co-opting science spaces" (p. 68) youth were "disrupting structures and identities" (p. 88) through their participation in science, which allowed them to "reposition themselves with respect to authority and take control over the spaces in which science learning happened in their lives" (p. 88) Their practice of science was mediated by the "activation of resources in non-standard ways" (p. 98) which allowed children to construct "relevant science" (p. 103). In order to make science relevant, youth enacted "transformations" (p. 120) of science and of their own communities. By co-opting science spaces, activating resources in non-standard ways to construct relevant science, and enacting
transformations both of science and the communities in which they lived, youth were creating a "community" (p. 153) that "reflected the kind of supportive structures, relationships and resources that sustained their practice of science” (p. 161). Those communities were determinate in terms of what science got done by the youth and why, as well as where.

In describing two practices of science, both studies appear to have metaphors related to where science is practiced (location metaphors), how it is done (methods metaphors), why it is done (purpose metaphors), and why it continues to be done (perpetuation metaphors.) Table 2.1 identifies the major metaphors in each broader category.

Table 2.1

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<td>location</td>
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<td></td>
<td>“circumstances” (p. 239)</td>
<td>“science spaces” (p. 38)</td>
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<td>methods</td>
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<td>&quot;operations on statements&quot; (p. 133)</td>
<td>&quot;non-standard ways&quot; (p. 98)</td>
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<td>&quot;use of credit&quot; (p. 192)</td>
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<td>purpose</td>
<td>&quot;solidification into fact&quot; (p. 76)</td>
<td>&quot;transforming community&quot;(p. 120)</td>
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<td>&quot;gaining credit&quot; (p. 192)</td>
<td>&quot;disrupting identities” (p. 88)</td>
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<td>perpetuation</td>
<td>&quot;creation of order from disorder&quot; (p. 245)</td>
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Because of the differences in position between the two sets of practitioners, neither
set of metaphors is more adequate than the other for explaining the phenomenon. The scientists in Laboratory Life (1986) conducted research for purposes of career advancement through the construction of scientific fact. Their interests were focused on this form of individual advancement. The authenticity of the problems the youth in Teaching Science For Social Justice (2003) constructed were a comparable source of their interest in their work. Barton (2003) explains that youth constructed a practice of science both as a means to negotiate the imbalances in power relationships which they encountered in their day to day lives and to improve the material and social aspects of the communities in which they lived. The youth in Teaching Science For Social Justice (2003) are compelled to do this for reasons not dissimilar to the reasons for a scientific paradigm shift (Kuhn, 1996). Differences between successive paradigms are both substantive with respect to nature and reflective of the science that produced each one. As Kuhn says, “They are the source of the methods, problem-field, and standards of solution accepted by any mature scientific community at any given time” (p. 103). Considering youths’ practice of science to be mature is somewhat problematic. However, the inability of school science to accommodate methods, a problem-field and standards of solution appropriate to their lives leaves many of the youth in Barton (2003) with no other choice than to embrace the opportunity to create their own scientific community for the reasons Barton describes. Their methods, particularly their disruption of structures and identities and mobilization of resources in non-standard ways reflect the impositions their status as children who are homeless creates. Their problem-field is not a factor of the work of other scientists as described in textbooks and journal articles, but rather their own concern for their living space and the community which occupies it. The scientists of laboratory life are motivated not so much out of a concern for the space in which they
work and the community of practice they share as they are constrained by it. They, too, have a problem field that is in many ways a factor of their material circumstances, in particular the apparatuses available for their work and their community as it expresses itself through research reports. Finally, the children’s standards of solution are less formal than those of a professional scientist, but are appropriate to their problem-field, which again is determined by their material and social circumstances. The youth are not necessarily creating a new scientific paradigm, but they are creating a practice of science which fits some of Kuhn’s criteria for one.

This stands in stark contrast to the normal scientific work of the endocrinologists of *Laboratory Life* (1986). While their work is specific to their lab, their methods, problem-field and standards of solution are wholly determined by their membership in the community of professional scientists. They are not creating a practice of science so much as they acting in accordance with the shared norms and beliefs of the culture to which they already have membership. Their work is a validation of their status as members of the community of professional scientists rather than an effort to forge such a community. In the case of professional scientists, the community precedes the practice, while in the case of the youth, the practice is for the sake of the creation of a more inclusive community and as an expression of their concern for the broader shelter community of which they are a part. In both cases, the knowledge produced is affected by the position of the practitioner with respect to one or more communities.

**C. Synthetic Statement of the two studies together**

The close examination of these two studies reveals that scientific knowledge is
produced through practice in the context of conflict and is the manifestation of a desire for authorship. Both the nature of the conflict through which knowledge is produced and the final products that result from the desire for authorship are the result of the position each group of scientists occupies with relation to the knowledge they produce. The metaphors in both studies locate and justify the conflict and resulting authorship by describing where science gets done, how it is done, for what purposes it is done and why it is perpetuated. In the case of the scientists in Latour and Woolgar's (1986) study, the conflict was internecine and intended to minimize the impression of authorship in the articulation of scientific fact. Barton's (2003) youth were in conflict with a larger system of institutional forces intended to serve their needs, but which instead often alienated or dehumanized them. They created their practice of science as a means to counteract that alienation and dehumanization.

While both sets of metaphors appear to produce adequate summaries of the two cases, neither set appears superior to the other because of some significant differences between the subjects. Initially, those differences led to a concern that the two studies were entirely too disparate to merit comparison. However, the elaboration of the metaphors helps to establish a connection between the two studies that is not vague and simply topical. Another concern, particular to this study, was a resistance to the notion that the science that youth practice ought somehow to be a less sophisticated version of that done by scientists. Privileging the account of the professional practice of science might reinforce this idea. Because of this concern, the general categories into which both sets of metaphors were synthesized were more influenced by the structure of Teaching Science For Social Justice (2003), inasmuch as the translation began with the metaphors from that account and sought to relate the metaphors from Laboratory Life (1986) to them first, then deriving the converse relationship
from what the first revealed.

The notion that scientific practice sometimes results in conflict is not novel. Kuhn (1996) describes conflict on a large scale as well elaborated paradigms eventually raise questions which they are incapable of answering and are eventually supplanted by new paradigms which accommodate the answers to those questions. The nature of the scientific conflict in both Latour and Woolgar (1989) and Barton (2003) is more local and particular. It is not the result of unanswerable questions, but rather the relationship between those people practicing science and the knowledge they mobilize and produce via that practice. Moreover, the conflict itself is constitutive of each group's practice of science in a way that Kuhn's normal science as an elaboration and extension of a paradigm is not. For youth, the conflict that gave rise to their practice of science was the product of their school and shelter environment, both of which marginalized them. They "co-opted science spaces" in order to alter the boundaries that existed as a result of the policies and procedures of their schools and shelters. They also acted to transform their community through their practice of science. In particular, the youth included as many people as possible in their practice of science and shared the fruits of that practice with the adult residents of their shelters thus transforming the community notions of who can do science. Materially, they worked to transform the urban environment in which they lived by cleaning and converting a nearby vacant lot into a usable community space.

In a similar vein, the scientists of Laboratory Life (1986) operated in a sort of virtual space, the agonistic field. The conflict which took place in that field revolved around the addition and subtraction of modalities to statements of fact, the success of which determined their future participation as practitioners of science. The conflicts engendered by their
operations on statements eventually were materialized or reified in the form of new laboratory apparatuses and procedures, both of which served to transform the physical space in which the scientists work. The fruits of their practice were more often than not shared within their professional community of practice through journal articles and papers. Occasionally they shared their statements of fact with the broader, non-professional community through articles in lay publications. Those articles served primarily to increase their credibility, particularly their access to financial resources/credit.

D. Authenticity Revisited

The above synthesis engages both science education’s concept of authenticity as an inquiry driven practice of science deriving its focus from the positionality of the inquirers and as a practice of science similar to that of professionals. In fact, what becomes clear is that the latter form of authenticity is achieved, in part, through the former. That is, both the professional scientists in Laboratory Life (1986) and the children in Teaching Science For Social Justice (2003) create their respective practices of science in light of their material and social circumstances. The children are authentically practicing science by virtue of the fact that they not only engage in the processes of inquiry articulated in reform documents such as the National Science Education Standards (1996), but also because their practice shares its origin in a kind of conflict and a desire for authorship.

This shared desire for authorship presents a possible third type of authenticity for consideration. As interpreted by Latour and Woolgar (1986), the scientific fact derives its validity from the removal of “modalities,” or traces of authorship and interpretation. Statements capable of standing alone without modalities appear stronger than statements with multiple qualifiers attached to them. Thus, while a research paper bears the names of its
authors, those scientific findings which become facts that are taken for granted often do not. This seems inauthentic inasmuch as it is a denial of the material and social origins of scientific statements, in essence a form of dishonesty. Here, perhaps the children, whose work often intentionally bears the marks of its authors, are more authentic in their practice of science than professional scientists themselves. They are honest about the origins of their work.

E. Conclusions

Some science education researchers view science studies as a means to humanizing the practice of science by giving science educators and their students a more accurate image of the work of professional scientists. This serves as a form of demystification, eliminating the image of the solitary scientist emerging from his lab with a great discovery to share with the rest of humanity. An alternative image science studies portray is that of scientific knowledge as hard won, not through conflict with an untamed natural world but through conflict and cooperation among practitioners. However, that scientific knowledge held to be factual is beyond reproach, in part, because all elements of that conflict and cooperation have been removed. In other words, scientific fact is dehumanized through the removal of the evidence of its construction by human hands. Such scientific fact is further removed from the human hands that constructed it through materialization/reification as laboratory apparatus. Each laboratory apparatus began as a literary inscription subject to debate among scientists in a larger agonistic field of their practice.

Those very students who might benefit most from a demystified vision of science viewed through the various lenses of science studies are often themselves dehumanized socially and economically by institutions designed both to make their education possible and
to further it. One response to this dehumanization is to actualize themselves via a practice of science. They find ways "to make their lives science" (Barton, 2003, p.163) in order to transform the world in which they live and to leave evidence of the human hands which effect that transformation.

Those researchers who hope to establish a relationship between science studies and science education for purposes of improving the access of diverse student populations to scientific knowledge and practice would do well to consider if there is a critical tradition in science studies that addresses how the relationship between scientific practitioners and the knowledge they draw upon, and produce, influences the nature of their work. As people intellectually positioned on the inside by virtue of their advanced degrees and specialized skills, it is interesting that they devote so much effort to anonymous, but seemingly universal statements about the natural world.

At the same time, researchers hoping to establish such a relationship would also do well to consider the interpretive nature of their endeavor. The description of particular practices of science holds more promise than attempts to enumerate its general attributes. It requires the admission that much of knowing is a matter of translating observed phenomena into terms that hold meaning for the translator, essentially making meaning of the world as it is observed. For purposes of acting in that world, synthesis of diverse accounts of that meaning making is useful for a number of reasons related to policymaking, improving practice and generally enhancing human discourse. Because science studies and critical ethnography, the fields from which Laboratory Life and Teaching Science For Social Justice respectively emerge, are explicitly interpretive, the aggregate logic of literature reviews does damage to the quality of their interpretations. Meta-ethnography holds promise as a means to
synthesize interpretive research for the purpose of illuminating the larger-scale relationship between science studies and science education. It has already found some use informing the practice of health-related professions such as nursing (Thorne, et al., 2004).

The synthesis of these two studies makes clear that while professional scientists and youth who practice science share an interest in authorship and forge that authorship amidst conflict, their purposes in doing so reflect their unique positionalities. At the same time, the synthesis reveals that youth may develop a practice of science in a resourceful and relevant manner, but an interest in transforming their communities for the better through material improvement and increased inclusiveness is what perpetuates that practice. This stands somewhat in contrast to Latour and Woolgar's (1986) professional scientists, whose work is perpetuated in the interest of gaining credit and advancing careers, with the creation of order from disorder as a by product of their ability to impose their statements on others.

Within the field of science education, this synthesis is also an attempt to engage in the ongoing dialogue with science studies in a new, more paradigmatically appropriate manner. A synthesis such as this requires a closer examination of a smaller number of interpretive studies than a large scale meta-analysis of quantitative data or a review of qualitative literature. At the same time, the insights a meta-ethnography yields are philosophically and methodologically sound, rather than the product of an academic ritual such as the literature review. While demonstrating a grasp of the research regarding particular topics is valuable and demonstrable through a literature review, it can devolve into a topically organized list of strengths and weaknesses of prior research rather than a synthetic statement. Meta-ethnography is intended as a response to the aggregate view of knowledge inherent in the list of strengths and weaknesses and holds the potential to illuminate the nature of science by
treating in a more interpretively appropriate and case-specific manner.

This particular synthesis highlights the relationship between laboratory science and a practice of science outside of schools. This is somewhat unique in the attempts that have been made to link science studies and science education, which have focused on ways to make classroom practice more authentic. That objective might be achieved through a closer examination of the practices of science constructed by youth for whom school science has not worked, and its relationship to the images of science provided by science studies. Future meta-ethnographies might incorporate accounts of classroom practices of science as well as accounts of field sciences. Doing so might reveal that the relationship between traditional laboratory sciences and school science differs from that of field sciences and school science.

More broadly, meta-ethnography might provide a more thorough elaboration of the range of meanings of authenticity in science education. Other qualitative studies might yield metaphors which, when synthesized, are more commensurable than those used here. Other forms of authenticity might be described by such syntheses necessitating the reconsideration of other issues within science education upon which multiple notions of authenticity might be brought to bear. An authentic practice of science which embraces a multifaceted notion of authenticity requires a reexamination of the nature of science and the forms of scientific literacy required for participation as well. Such reconsiderations could serve as a further impetus to changes in classroom practice, particularly increased inclusiveness.
References


