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Special Series on Arts-Based Educational Research

Art In Science?

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ABSTRACT

This article presents the results of a study of artistry in the practice of research in the social sciences. Traditionally, science and art have been regarded as complementary, one dealing with the expression of feeling, the other with the pursuit of truth. Art, it is widely believed, is largely ornamental in life—nice but not necessary; science is critical to the future. Yet science has a personal side as well as a public one. What is the personal side of science like for those engaged in research in the social sciences? Do artistic considerations function in doing science? If so, where and when? We interviewed social scientists who were fellows at the Center for Advanced Study in the Behavioral Sciences to secure insight into the role that artistry might play in the course of their work. This article describes what we learned.

I

Science and art have long been regarded as belonging to different worlds. Most people associate science with spacecrafts, treatments for deadly diseases, laboratories, the study of nature, and other human efforts to understand the world by understanding how it works. Science is thought of as an enterprise concerned with discovering what is true. It requires evidence to support one's ideas or claims, it uses methods that can be replicated by others, it yields general ideas about a domain of study, ideas related to theories that provide explanations that have some instrumental utility and that satisfy our rationality. Science for the person on the street is a technical enterprise requiring specialized training and that eventuates in publications that only the scientifically literate can read. Science is serious business. Science and its discoveries are considered critical for our future.

Art, by contrast, is not so somber. Art, it is widely believed, is not concerned with truth but with beauty, it is intended less to inform than to please. Art, for the average American, is based on taste and personal preference; it appeals to the senses, it addresses particulars, it is the product of a largely unlearnable process. Art requires talent. And while art is a source of satisfaction, it is not a necessity; it is nice, but not necessary.

The grounds for the distinctions between art and science are venerable. They go back to Plato's theory of ideas and his belief in the need for those who would seek to truly know to relinquish dependency on sensory experience in order to ascend to a realm in which pure intuition of *eidōs* could occur. The sensory addressed the material world, a world that is fugitive. Secure knowledge, real knowledge, could not be attained by a dependence on what was not stable. Genuine knowledge required the highest form of rationality. This form of rationality trafficked in abstraction.

But it was not Plato alone who contributed to the distinction between art and science. The distinction was reinforced further with the shift in thinking represented in Galileo's and Descartes's contributions as well. With Galileo, according to Dewey, came a shift from the qualitative to the quantitative, from the appreciation of particulars to an interest in relations and abstraction. Indeed, the project of the Enlightenment was to discover what was orderly about the universe and to create an encyclopedia that would catalog the facts as discovered. Art had nothing to do with it. Stephen Toulmin (1990), the noted philosopher of science, describes the agenda of the Enlightenment as moving from an emphasis during the Renaissance on the oral to an emphasis on the written, from an emphasis on the particular to an emphasis on the universal, from an emphasis on the local to an emphasis on the general, and from an emphasis on the timely to an emphasis on the timeless. In short, the Enlightenment was built on a desire to achieve a kind of bodiless abstraction representing the apotheosis of theoretical science, which, of course, is best exemplified today in theoretical physics.

Plato, Galileo, and Descartes represent efforts along our long cultural history in the West to define the conditions of knowledge, but more recent efforts emerge in the work of the positivists, particularly those belonging to the Vienna Circle during the first half of the 20th century. These philosophers carried on the traditions of the Enlightenment by their interest in excising from philosophy all forms of metaphysical language in order to advance a conception of scientific rationality free from forms of feeling that they believed had little or nothing to do with matters of truth. Herbert Feigl, Hans Reichenbach, Otto von Neurath, Rudolf Carnap, and others had a vision of the possibilities of science and pursued a conception that would, in their view, culminate in a unified theory of science. This theory would be comprehensive and would not only be spare, tidy, and orderly, it would bring all knowledge into a logically constructed theoretical whole. Artistry was simply not a part of the conversation of what science entails. Indeed, the separation was so significant that it represented for some a conceptual breach in our culture, a breach described in C. P. Snow's *Rede*

Lecture at Cambridge in 1959, a lecture titled *The Two Cultures and the Scientific Revolution* (1959).

One of the consequences of the separation of art from science for education, particularly for science education, was the neglect in our own field of the place of artistry in teaching and learning science. Aside from Harvard Project Physics, there is no work we know of that was aimed at developing curricula that brought artistry into the conversation about the conduct of science. And in Harvard Project Physics, the curriculum project that comes closest to addressing the arts in science, the resources were largely historical rather than addressed to the aesthetics of scientific practice.

The distinctions that we have inherited between art and science have led to a general neglect of their common features. Which features are common to both is significantly influenced by our conception of what counts as art and science. Our own view of art has been influenced by John Dewey's aesthetics. Dewey held the view that art is a particular quality of human experience that to some degree could be present in any interaction an individual had with the world. Art, Dewey argued in his epic *Art As Experience* (1934) was not the sole possession of a unique class of objects hung in museums, but a living process that humans experienced when a certain quality of attentiveness and emotion were a part of the engagement. This process is prefigured in the focused and taut attention of an animal stalking its prey and in the utter absorption of a toddler playing with sand. It appears in the work of a gardener devoted to the care of plants and is displayed by the amateur mechanic who lovingly ministers to a car. Dewey sought to reestablish a connection between art and life. In fact, he believed that putting the arts on a pedestal impeded our understanding of them and it was precisely this pedestal-placing activity that he claims most aestheticians engage in.

Just what is science as a form of human experience? What does the scientist undergo in *doing* science? Taking Dewey's lead we began to ask if the experiences scientists have doing science have artistic features. In a sense we are interested in the personal, as contrasted with the public, side of science. The public side of science is the science we experience when reading a scientific publication or hearing a scientific paper delivered from a podium. It is a talk at a conference, a report to colleagues, regardless of how informal. The public side of science has as its aim the disclosure of what has been learned.

The personal side of science, what we seek to understand in our current study, is more intimate. Our focus is on the scientist's experience. We seek to answer questions such as: Where in the course of one's research are satisfactions secured? How are choices made? What is a good day like? How, if at all, is somatic knowledge used to make decisions? How do scientists arrange the settings in which they work? What motives drive their work? We are interested in casting a wide net that might pick up clues about the forms and qualities of experience scientific investigation generates, especially its aesthetic or artistic aspects.¹

Although the phenomena in which we are interested are wider than Dewey's conception of art as experience, we hope that attention to a broad view of the scientist's experience might shed some light on why they inquire, that is, on the motives behind scientific inquiry, and what they get from doing research.

Scientific research can be thought of as a practice, as something done over time. It could be argued that the conduct of any practice can be thought of, at least potentially, as an art. From a theoretical perspective, a practice considered as an art is a practice riddled with uncertainties, marked by surprise, motivated by the satisfactions of discovery, supportive of innovation, and prized for the experience it makes possible. But is it? What do scientists have to say about their working processes? What account do they provide of their work in progress? Do they themselves think about their work as an art or do they think of it as a craft, or as neither? Our work is intended to shed some light on these questions.

Why, one might ask, would we want to know about the experience scientists have while pursuing their research when what matters is their work, not their experience doing it? We believe that understanding the qualities of experience that the process of doing science generates is important for a variety of reasons. Of course, at one level, the effort to understand the factors that come into play in the conduct of any socially important activity needs no further justification: the enlargement of human understanding is self-justifying. Yet, it seems plausible to suppose that the quality of the work created is related to the quality of the experience made possible by the processes that scientists employ. If those experiences and processes can be better understood, perhaps they might be more effectively promoted. This possibility is especially important to those whose professional aim it is to promote expertise—teachers—and to those whose aim it is to understand the features of expertise—educational researchers.

It is also important to try to secure a more replete conception of scientific investigation. Partial views—and we will always have them—are less useful than those that are replete and robust, if for no other reason than that they provide a better sense of what inquiry looks like from the scientist's personal perspective. As we said, typically our attention has been focused on the products scientists create and the procedures they employ rather than on their personal experience in the enterprise.

Another reason for this inquiry pertains to the cultural and historical separation between art and science that we mentioned earlier. It might be that artistic modes of thought and aesthetic forms of experience perform an important function in doing scientific research. It might be that somatic forms of knowledge—the use of the physical body as a source of information—play an important role in enabling scientists to make judgments about alternative courses of action or directions to pursue. It might be that qualitative cues that are difficult to articulate, indeed, cues that may themselves be ineffable, are critical for doing productive scientific work.² And, perhaps most important is the possibility of discovering that reasoning with and about sensory qualities is inseparable from what we usually regard as

belonging to cognition.³ Indeed, perhaps the content of such reasoning is feeling. Put another way, by studying what scientists have to tell us about their experience doing science we might be better able to determine if aesthetic forms of experience contribute to an enterprise that is typically contrasted with the arts.

We have so far used the phrases *aesthetic forms of experience* and *artistic modes of thought*. These terms are not self-explanatory. By aesthetic experience we mean forms of experience that possess an emotional quality that is both feelingful and satisfying. The word aesthetic has as its antonym the word anesthetic. An anesthetic is a suppressant of feeling, whereas an aesthetic engenders it. But in our culture "aesthetic" is associated not only with feeling, but also with satisfaction. Works or situations we describe as aesthetic are works or situations we tend to value because we value what they do to our experience. Does the conduct of scientific research provide such experience? If so, when, where, and in what way?

The term *artistic modes of thought* pertains also to the quality of experience, but is more closely associated with experience that is used to make decisions about which courses of action to take in the conduct of one's work; a sense that this choice is better than that one, that this fit is better than another, makes decisions possible that cannot be made by appealing to rules of logic or to the probabilities secured through inferential statistics.

We also mentioned that we are interested in cognition. It could be said that the deep agenda of our work is to broaden and deepen our conception of cognition by helping to determine if what we call the aesthetic and the artistic are central, marginal, or absent in the experience of scientists who do research, a process regarded as the apotheosis of cognitive functioning. We are interested in identifying the ways feeling functions when scientists address complex problems. Such an aim, if realized, might help us form not only a more complete view of what it means to do scientific research, it might help us form a more adequate conception of how humans think.⁴

Perhaps art and science are more closely related than most people believe. Perhaps many of the most important choices scientists make during the course of their work depend on the feel of the alternatives rather than on, let's say, strict logical deductions. Perhaps what philosopher Nelson Goodman refers to as a feeling for "rightness of fit,"⁵ might be as important an influence in the conduct of inquiry in the sciences as it seems to be in the arts. Perhaps one of the primary sources of satisfaction in science is pride in craft, in the aesthetic satisfactions secured from the skillful use of tools, conceptual or otherwise. This is the arena in which our work has been undertaken. It is an exploratory effort.

II

The population for this study consists of 30 social scientists who were, at the time, fellows at the Center for Advanced Study in the Behavioral Sciences

in Stanford, California. Selection as a fellow at the Center is the result of a careful, rigorous process that yields both senior and well-established scholars and younger scholars whose promise is so great that an appointment at the Center is believed to be useful in helping it along.

Each year about 45 fellows representing almost all of the social sciences, some humanities, and professional fields are selected. They arrive in September and stay for about an eight- to ten-month period. The Center provides office space, a library, access to the Stanford University library, some secretarial and computer assistance, and lunches intended to foster dialogue among the fellows. Fellows have no formal obligations aside from making their stay intellectually productive.

Letters describing our interest in talking with them about their experience doing their research were sent to all the fellows. Those who accepted our invitation were contacted by phone to schedule interviews. During the first round of our research, interviews lasting about an hour each were held with 20 of the fellows. During the second round, multiple interviews were held with four of the fellows. In all cases the tape-recorded interviews lasted from about 50 minutes to an hour and 15 minutes.

Each interview was transcribed and read both independently and jointly to identify responses related to our research interests. The criteria we applied to the interview protocols pertained to statements that expressed feelingful features of their work or their imaginative aspects. Each of us independently read and identified such features and then compared our judgments, eventually categorizing the data based on emergent themes.

There are a number of features in the methods we used that warrant explanation. One of these pertains to the criteria we used to identify sections of the interview that represented experience close to what we were interested in. We did not have explicit criteria. Our call was based on judgments about what they had to tell us for which we could provide reasons. We did not know what we would find in any particular interview and therefore tried to let the data speak to us. This way of treating information resembles the work of a critic who cannot know in advance which particular qualities a specific work of art or literature, music, or dance might display, yet is responsible for recognizing what is important in the work and justifying his or her judgments if asked (Eisner, 1991).

A second issue pertains to the context in which the interviews were conducted. Did those with whom we had conversations know what we were interested in? Yes, they did. Although we did not emphasize our research aims, we did tell them we were interested in the quality of their experience doing research and that we were particularly interested in the extent, if any, to which artistry played a role in the practice of their work. We did not want to deceive those who gave us their time and attention and, knowing the sort of scholar the Center attracts, we did not believe that they would feed us false information to accommodate our research agenda. We could be wrong on this matter but there is nothing in the interviews to shift our view. Indeed, the responses during the interviews seemed very candid.

Before discussing what we learned, a word needs to be said about the character of our conversations with the researchers. We say conversations rather than interviews because we tried to keep our discussions of their work and experience as conversational as possible. This meant that while we did not have a schedule of questions to follow in a predetermined sequence—we wanted these conversations to have a natural or organic quality—there were a number of questions we wanted to ask. For example, we started our conversations by asking them to tell us about their work. We wanted to know where their satisfactions and frustrations were located in their work. We asked them about how they thought about the writing process, how they conceptualized their research, the basis upon which they edited their work, whether they thought the process of doing research could be described as a craft, an art, or neither. We wanted to know how they knew they were on to something, that the road they had taken was headed in the right direction. In no case did we feel compelled to ask all the questions we formulated to all the social scientists with whom we talked. As we said, we wanted the tone to be conversational and to achieve that aim we needed to follow their lead.

In the material we have presented so far we have described the problem we have studied, its significance, and the way our inquiry has been organized. We now turn to the conversations we had with the social scientists about their work and what we discovered. In doing so, we discuss some of the themes that emerged during our conversations.

III

One place to begin to discuss the role of artistry and aesthetic experience in social science research is with the way research is conceptualized and designed. We asked one of our social scientists: “What’s it like for you to have formulated a concern, recognized a possibility, but to not yet have a study?” Her response is worth quoting at length.

That’s an interesting question. I have a pretty rich mental life. I have a peripatetic mind and it doesn’t shut off. So I do a lot of mulling in my head. I don’t tend to put things down on paper right away; I know some people do this, they’ll make notes. Occasionally, if I am trying to understand relationships among parts of the system, especially because I do a lot of policy research, I will try to lay it out graphically, try to envision how various things connect to one another. What might influence one thing and another. So I’ll often lay out schematics and play with those if I am looking for a relationship to questions. But if I am doing a piece of empirical work, I think I do a lot of the conceptualizing mentally and I mull it and mull it and mull it. It is, in a way, like creating music.

When I did a fair amount of composition a long time ago when I was studying music, you hear a theme. Like hearing this question, you say, “This intrigues me”. And you hear it and then you develop that a little bit in your mind. It’s almost an aural thing for me, but it’s all in the mind. But I also talk about it, so it’s oral in that sense; you put it out there, you have to get it into the world, to take it out and to look at it once you start talking about it and thinking about. That theme then begins to elaborate. And then there are some harmonies that develop because you

sort of see there are strands of the idea that go together. It's not just one idea. That's a little bit of counterpoint that is a little fugal for me because there's an idea, and then it interacts with itself in a certain kind of way and kind of eventually begins to take on some form, just as music does. When I develop music it takes on a form of its own, it doesn't spring formed into my mind. It has a process by which it eventually becomes a set of measures in a stanza, if you will.

That visualization should be significant in the planning of a research effort and in writing is not surprising. One of the features of language is that it is diachronic; it develops over time. Some relationships are more readily examined when the form is displayed synchronically rather than diachronically. When visual images are generated, relationships among the several "parts" can be examined simultaneously; they can be reflected upon. Imagination not only gives us a glimpse of possibility, it provides us with the opportunity to examine relationships as they interact, something that diachronically organized material does not do quite as well.⁶

But using sound to characterize one's thought processes when conceptualizing research, as this social scientist did, is surprising. We usually don't think of our thinking as a fugue. Yet, in retrospect this, too, seems appropriate: in music as in life outside of music there is hardly any variable that stands alone. In a fugue there is a rich simultaneity that parallels some of the design considerations in research.

Is there artistry in the encounter just described? If art includes the skillful crafting of imaginative material so that the relationships become coherent and emotionally satisfying, it seems to us that the processes our social scientist described would count as an instance of artful thinking in action. Judgments about the rightness of fit among the dimensions or variables entertained have similarities to judgments about the composition of relationships in a fugue. Both can yield aesthetic satisfactions.

Speaking of the crafting of material brings us to the writing process. There were a number of responses to our questions about writing. One social scientist was asked, "Let's talk a little bit about writing, and your experience as a writer. How do you get into it and what do you do to write? Do you use outlines, how does it come out, so to speak? What's the editing process like for you?" Our conversation went as follows.

Scientist: For me, when I do the kind of expository research work, I do tend to start with an outline because I've got this kind of structure and set of ideas in my head, so I try to start with, well, what are the main ideas, what are the chunks that I want to write with? I occasionally have imagery that I want to get down on paper. I have pictures of classrooms or insights.

Interviewer: Are these visual?

Scientist: Yes, it's very visual. Pictures of classrooms. And I want to convey that like the book that I just did last year. It starts with a picture of a classroom. And it helps me to understand the dynamics, and I hope that it helps other people to see it in a very visual way. Then you can talk about the data and the principles and the propositions that are somehow embedded in that picture. So I collect those little pictures, too, and I am not always sure where I am going to use them

or how I am going to use them, but I know they are intended to illuminate the more static outline that I am chugging through.

The conversation moves on to a discussion of editing.

Interviewer: Tell me about your engagement in editing.
Scientist: I am obsessive and compulsive about editing. I make everyone around me crazy, and myself. It's also very satisfying to me. It's like doing the *New York Times* crossword puzzle. It's crafting, it's polishing, it's getting the wording so that it's aural. I listen to the text in my head, you know, to see if it has a right ring, you know? If it sings as well as it conveys the idea precisely, it's both of these things. So there is a typical research temperament that you want to be clear, tempered, accurate, precise about what you say.

Note that while the desire for precision is one part of the process she mentions, she also mentions the satisfactions received from polishing, from crafting, from getting the "right ring." What she seems to be saying is that melody seems to count.⁷

Comments of a related nature are made by a distinguished archeologist. When asked about her writing, she responds, "Well, what's going on there, and I think other people don't have this—but I *hear* it. I *hear* a word that doesn't belong so then I sit there and think about the word that doesn't belong and that is fun. But other people, they don't hear when they write."

Here the imaginative process in complex auditory tonalities enables her to achieve the cadences she wants. The sensory qualities as well as the logic of language are monitored and constructed to give the reader what she wants them to have.

What these social scientists tell us is the importance of qualitative considerations as a way of bringing meaning to what otherwise might be dry prose. Again, imagination and sensibility operate to make vivid the scenes and situations our social scientists usually address more abstractly. As a result, there develops a kind of dialogue between the concrete particular of the prose itself and the abstract universal its meanings are to adumbrate. Meaning is enhanced through the interaction of word, sound, and image.

These social scientists also commented on the qualitative aspects of form and structure. One of our social scientists was asked, "Are you relying more or less on outlines now as a structure for your writing than you did 10 or 15 years ago?"

Scientist: Maybe more. Maybe that's kind of a funny thing because I give myself more leeway to pursue my ideas, but then I have to have some kind of big structure to return to so that it hangs together. And having the outline enables me to be more free, but when I say an outline, I'm talking about a napkin that has, like, seven points.

Interviewer: It's improvisation?

Scientist: Yeah, there's a lot of improv. in there. Not like when you were in high school and teachers said you had to have Roman numeral IA, 1, 2, 3, B, 1, 2, 3. I do sometimes have things like that, I mean I do say, "Okay, when I make this point, I want to make sure to touch on

these three issues”, and so on. But I have a skeleton structure that helps me make sure that the work is going to connect.

What we see here is an effort to provide enough structure to secure coherence, but not so much as to stifle flexibility. Art loves chance, said Aristotle, and this social scientist wants to make sure that chance has a chance.

Related to the communicative impact of sound and image is a recognition of the importance of what might be called “storied accounts” of the research undertaken. One social scientist was asked why there was a literary interest in writing.

Scientist: It’s fairly easy because if you’re interested in stories, then you cannot avoid reflecting on your stories as literary documents. They should be convincing, not only in a scholarly way, but in a literary way.

Interviewer: That’s important to you?

Scientist: That’s very important to me, to dramatize the writing, not simply the story, but the whole writing. To have a dramatic structure.

When asked whether there is some particular cognitive function that a literary form performs, our social scientist responds, “Yes, I think so. I think that literary qualities might bring the story closer to the reader, which would allow the reader to see certain aspects that would otherwise be difficult to see. And especially in my case because I am writing about the events of recent [European] history . . . which the public tries to avoid and forget very forcefully, and it is a challenge to try to force the reader not to forget. Thus, the literary treatment of a narrative becomes a way of forcing a reader to remember what he or she might otherwise want to forget. It helps it become memorable.”

To the extent writing is crafted with an eye to its literary qualities, aesthetic criteria are at play. What we think is occurring is a tacit recognition that communication exists at many levels, one of which is the emotional. At an emotional level the organization of prose engenders feeling, which is a critical part of the process of research, at least for some of our social scientists. But to achieve an emotional impact the work has to be monitored and appraised with respect to its aesthetic qualities; the writer has to feel what the work feels like.

We turn now to see what some of these scholars had to say about the settings they find or create for doing research. One of our scientists is a world-famous student of the behavior of dolphins in their natural habitat. One of the important sources of aesthetic satisfaction for her is the habitat or environment in which she works. She commented, “I go to west Australia to do the research. It’s a beautiful area. It’s a good reason to pick big dolphins.” Later, when asked to describe a good day in research she said, “A good day is when the water is like glass all day long and I spend about 10 hours with a particular infant.”

For her the setting in which she works matters—the aesthetic qualities of the environment count. But not only does the environment count, the

opportunity to really get to know the animals as individuals matters. She was asked, “How important is this aspect of your research life, that you get to know these, in your own words, individuals?” She replied, “I think it is very important. . . . It is knowing the individuals and what happens to them that is part of what keeps me going.” Indeed, she said later, “I can remember almost every follow and I’ve done hundreds of follows. I remember each one.” We asked her if she had such a memory for humans and she replied, “I’ve wondered about that. Not really. I tell my graduate students that if they all had dorsal fins I could recognize them!”

What we have here are two features of her research that are sources of deep satisfaction. One is the place itself, the kind of beautiful environment it is. The other concerns the ties of affection rooted in the perception of individuality that the creatures themselves make possible. This student of dolphins has learned how to notice the individuality of the dolphins she works with—even more, it seems, than the individuality possessed by her doctoral students!

The setting in which social scientists work is important not only for a student of dolphin behavior who spends much of her time on clear waters under a bright blue sky. It also matters to academics who work in their offices or homes. When a sociologist was asked to talk about his experience in writing and the setting in which he writes, he commented as follows:

When you get this great line, Oh boy am I happy about that! Just a phrase or something where I say this is great! And also the other thing is just being an academic. The conditions of work. The immediate conditions of work—I really like them. To be sitting there and to be able to look at my own little owl, or to drink my orange juice, or listen to the radio, which I tend to do. Though my mother used to say, “Don’t do your homework listening to music,” she never convinced me of it. Looking at the artwork. I’m free! I’m able to work on my own schedule.

This sociologist is a nest builder, someone who takes pleasure and comfort in the setting he creates for himself. Do these matters count as examples of aesthetic experience and artistry in doing research? If the qualities of place matter in doing one’s intellectual work and if the satisfaction of knowing what is unique about individuals—even if they are dolphins—are indices of the aesthetic, if being touched by a well-turned line matters, then such aspects of the researcher’s experience can be regarded a part of the aesthetics of the research process.⁸

These “soft” features of the research experience by no means exhaust the sources of aesthetic experience in the conduct of research. The drive for achievement, success, triumph, and getting there first also emerged from our interviews. For example, when we asked our student of dolphins about how she forms the problems she studies, we had the following conversation.

Scientist: Well, a lot of the problems came after we did the first year of research on them because nothing was known about these animals. I am the only person who has studied them from birth to weaning.

- Interviewer:* Was that attractive to you?
Scientist: Yeah. That's completely new. Everything I say, I mean, I know things nobody else knows.
Interviewer: You feel a little bit like Columbus?
Scientist: Yes, a little bit. It's a discovery. To have no competitors is a nice feeling. I like that.
Interviewer: It looks to me as if you have a corner on the market.
Scientist: Yes, I do. I know I do. I don't mind. I like it. I don't complain. But it's fun.

Getting there first matters to her—and it matters to others we interviewed. There is the sense of challenge, the feeling of being in a race, an adrenaline flow stimulated by the contest.

Still another example of the joy of having virgin territory to explore is described by a prominent educational psychologist regarding his work in a field for which he had no specific subject-matter background, namely, social studies.

I was at a point where I knew that if I wanted to continue with the cognitive or subject matter aspects of my work, I was going to need to get into a subject-matter. So I volunteered to be the person, we got the grant, and I spent a year tooling up, reading a dozen or so methods texts and some other key texts in the social-studies and reading journals in the field which is relatively easy—there are only a couple of social studies journals. Basically swallowing all there was around and digesting it.

I spoke to some of the leaders in the field and corresponded and managed to get up to speed pretty quickly because it was so small, not small in the school curriculum, but it is remarkably small in the scholarly community. There are probably four, five or ten people in reading and math to every one in the social studies, for historical reasons. That shouldn't be, but that's the way it is.

So, to me this is candy land. It was a way for me to do something that I felt was important, it was virtually virgin territory as far as scholarship in the field. In fact, many of the things I'm doing, unlike earlier in my career, are applying the basic ideas in methods that have been used already in science and math.

The analogy of being in a candy store where all the candy is available and easy to reach suggests a sense of excitement, joy, and anticipation. In addition, because he believed the field of social studies research to be so limited with respect to its research base, he would also be the first to do the things that he believed needed to be done. In fact, he said, "If I have a sense that I'm going to do something that has never been done before, or that has never been done this well, or whatever, that adds a certain pleasure to it, I guess." Again, getting there first matters, not only in studying dolphins, but doing research in the social studies.

The discovery of patterns in one's data is another source of excitement derived from exploring new territory. An archeologist, when asked about the particular aspect of her research that she finds most exciting said, "People always ask me what's the best thing I've found. I say a pattern in my computer printout and they are very disappointed. And they say 'No, really?' And I say, yes, really. One of the things that always astonishes me is patterning in data 500 years or 1000 years later. It just seems so improbable

to me that once I find a pattern I really get excited, especially one that I predicted!"⁹

But she followed up quickly with the observation that satisfactions and excitement are not the only things that it's about. It's also about being scared. She commented, "It's scary. Just because you did it once doesn't mean you can do it again. Right now I'm very scared because I've been putting in all this time reading and I should be starting to write and I don't know if it's going to work out, so it's scary. But most of the time I'm successful with coming to some new kind of resolution of this problem and then it's exciting."

For her there is an oscillation between a process of searching and a fear that what she seeks will not be found. It is precisely this interplay between problem and resolution, the search and the find, the hunt and the capture, and the ever-present possibility of coming up empty-handed that creates the aesthetic and emotional dynamic that researchers seek.

As for the connection between art and science, one quantitatively-oriented cognitive scientist commented, "I am an honest-to-God scientist in the same sense that scientists are in any field and I think they kind of recognize one another. I view that as the way that my particular talents and interests combine to allow me to make the most important and lasting contributions that I would make compared to other things that I might do. . . . And I view that as an important part of what I do and there is some artistry there. There is some risk there. People who have taught rigid views of science and how to conduct and report science would view me as being unscientific. [Artistry in science consists of] the seeing of patterns and linking the pieces and pulling together all that different stuff to make sense out of it."

What we have is a common task shared by artist and scientist, Both are concerned with the creation of form—one qualitative, the other theoretical—and they prefer, both artist and scientist, that their forms be beautiful because we believe they know that the attraction that a theory has is not solely a function of its predictive power—especially in the social sciences.

As we have learned from our interviews, for many social scientists getting there first matters. Finding new territory, creating new questions, discovering new patterns, and succeeding in what is a competitive race are a part of the social conditions for social scientists. We believe that like the rest of us, social scientists doing research do not leave their humanity behind them. Again, coming in first matters.

We have previously discussed the importance of creating an environment conducive to good work as a kind of nest building, but environments can be mental as well. They can involve establishing personal rituals, habits, or routines that constitute a kind of cognitive "warm-up." For example, a psychotherapist we interviewed spoke about several processes she employs in order to prepare herself for the task of writing. "I imagine myself sitting in front of the computer writing. This is a kind of warming up process, [to] put my mind into that mood and prepare my mind to go rather smoothly when it comes to writing. I imagine in my mind the kinds of books or

articles I have to collect [in order to] write. So that is the preliminary phase. Then, when I sit down, already it is at the point when I feel a kind of urge.”

Similarly, she prepares her state of mind before she enters an interview with a client.

Before I start an interview I try to put myself into this kind of state of mind,¹⁰ to make myself flexible and open and sensitive and receptive, so not to think about that I have to finish this thing, or what is my next stop, or I have to finish it in time. Of course you have to be aware of time, but still, somehow concentrating on the forthcoming experience.

In addition to these strategies, she also sings while doing her work, a process that goes on simultaneously with her writing, mirroring the writing process as well as encouraging her. For this social scientist, a necessary part of cultivating her ideas is cultivating a state of mind that will be receptive to new ideas. She evokes certain emotional qualities that help her to write or prepare her for an upcoming task. Over time, these patterns develop into certain rituals and repertoires that eventually contribute to competence in her field.

An educational policy analyst also cultivates cognitive habits that advance her work. She stated it this way.

I've learned in my temperament that I'm more productive if I allow myself to engage the text that is mentally at the front of my mind, that I feel mentally ready to engage. Taking advantage of your own teachable moments.

Another instance of personal knowledge.

Taking advantage of her own teachable moments has led this woman not only to develop a competence in making judgments about her work, but also to know when to employ certain forms of cognition that will aid in her decision making. For example, when things are going smoothly in her work, she stated, technical skills are all she needs to use. “However, when you have obstacles, then you have to use your skills in a much more creative way, and then you have to use your sensibility and your whole personality I would say. So you have to use your own resources in a very complex way.”

Using her “whole personality” is different from using just her technical skills. Here, she relies on other ways of thinking through problems that supplement or even override technical skills: one's personality consists of such aspects as past experiences, emotion, intuition, predilections, behaviors, and attitudes. In this way, judgment and progress are aided by phenomenological experiences as well as by technical skills. Drawing on one's resources in a complex way requires a nuanced understanding of the medium in which one works, involving not only technical skills and prior knowledge, but also a feel for the medium.¹¹

Cognition is also informed through social interaction. Several of these social scientists rely on the feedback of colleagues to aid them in their

research. The role of colleagues is an important feature of the cognitive environment that these social scientists wish to create. Colleagues function as a testing ground and help to remind them of the established norms, trends, and theories that constitute the culture of their respective fields.

One social scientist described the role her colleagues play in her research in this way.

Often ideas percolate in my mind sort of solo for a while. Then I start to talk to people about them, people I respect, about the ideas and ask, what do you think about that? I develop them in collaboration with other people. Then I will try to recruit people to do the work with me, who I think have the skills and the concerns that I think would enable us to work together on it. But I typically develop the ideas for things I am passionate about in my own mind and experience for quite a while. [Then] I usually create a group within which to do the work.

Establishing a frame of mind that prepares one for the work ahead, developing a cognitive style upon which one draws for future decisions and judgments, and working with colleagues in order to test ideas and situate them in the larger field of which they are a part contribute significantly to modes of thought that are both aesthetic and artistic. These social scientists draw upon and evoke emotions that prepare them mentally for their research. Artistic modes of thought are involved in nuanced judgment calls, in the decisions that must be made despite absent or inadequate data, and in addressing the obstacles to one's thinking.

Aesthetic considerations and artistic forms of thinking appear not only in the construction of the text, but in the construction of the ideas that will form the core of the research study. The following narrative, taken from an interview with an archeologist, reveals the importance of personal experience and insights in relation to the construction of research and analysis. The archeologist was asked if there is any craft involved in her work.

Archeologist: Yes, there really is. I think one is the formulation of the question and another is putting together little bits of information to build a story for an article, let's say. That's another. . . . One piece I wrote was about what happened to women in areas that had been conquered by the Aztecs, the consequences of imperial rule through women's lives. And so I started out knowing that I had cooking pots and spinning tools. Women did the spinning and weaving. OK, I thought, I've got these two areas. I can talk about women's lives. I can look at changes in these two areas. Then I thought, well then I'll look at them together and think about if they had to do more spinning they would have to change their way of cooking. Not just keeping them separate, but thinking about how they interrelate.

Then I thought and as things went on it became clear that I had different patterns developing partly on ecological circumstances and partly on geographic differences from the core versus a periphery kind of thing. So realizing what was going on, I began looking for those kinds of things. It seems that that is a part of a craft and then making that part of a story, incorporating that. Finally, contrasting the variability of the archeological record with

the ethno-history record and the historical documents where you have men writing about women. So the whole thing made a nice little article. . . .

I create data points. You know, like nobody else ever asked if cooking routines ever change when women get conquered. Nobody ever asked that. Nobody ever broke down the data by those time periods in different cooking techniques. Most men don't even know that food has to be cooked!

Interviewer: OK, what's the importance of knowing? We were talking earlier about asking questions and that there are different kinds of questions to ask. Why is it important to know that?

Archeologist: This cooking thing also came out of my life experience. If you're spending more time on your job you have less time to cook so you end up cooking differently. So what you cook depends on what's on sale, whether you need to take the meat out of the freezer, how much time do you have before the next meeting, and so on. I sort of think cooking is a strategic activity. Which means it's going to respond to environmental variables. I think men just think it's food and that there is no thought of what goes into it. I just thought about the various kinds of foods, how the pots are, and whether those ratios would ever change over time—and they do. What's the main strategic thing going on? We'll, they have to weave more tribute cloth. In areas where you get a big increase in weaving tools, you get a change in cooking.

Clearly here is another example of imagination at work; this time enabling the archeologist to connect her own life experience in modern-day America with Indian life 1,000 years ago and thus to raise archeological questions that nobody asked before.

When prompting the social scientists for their personal histories, each of them discussed their backgrounds in terms of early identification with either a professional domain or a particular idea that became important to them at a later period in life. Some of our interviewees stated that they were recognized by their peers or teachers as being good at something, which motivated their interest and competence in a given domain even further. For example, when asked, "If you were to think about matters of identity or selfhood, when did you begin to think about yourself as Mr. Scientist?" (a term he used to describe himself as a child).¹²

Oh, yeah. Sure. At two levels. First of all, I knew what I was interested in and there was no question. I wasn't doing electronic stuff just because somebody said it was good for me or that it was science. It was just interesting and I liked it and I wanted to do it. Mainly, I wanted to build things. It wasn't so much the purely intellectual knowing, but I was always aware that among my peers and teachers I was defined in part as the guy who's interested in science and good at science. There is no question that I knew that.

This cognitive scientist revisited this theme in a later interview and built on other concepts that he has identified during the interview as intrinsically rewarding. Commenting on his work at a university artificial intelligence lab, he stated:

Part of my transition into education was a kind of deliberate playfulness [I observed at the lab] that I thought was neat. This resonated with me partly because of things that were a kind of culture of knowing and thinking that I grew up with at Princeton as an undergraduate, which was very different from a lot of ways that people think science ought to be done. You know, there is a playfulness.

Sometimes, a person may not recognize himself or herself as an expert, but instead recognizes an idea, theme, or concept that is intriguing and leads to a professional discipline. When asked what attracted him to history, a historian we interviewed recognized an aspect of his life that intrigued him as a young person.

My mother is an art historian who used to teach history. I have always been attracted to stories. I very much like real, concrete stories. I'm very much interested in my world. The time [in which I live is one] I try to always understand.¹³

The fact that his mother is an art historian no doubt influenced the direction he took with his ideas, and his identification with the domain of history remains strong.

When I'm engaged in this work, I'm usually mostly self-reflective. So, perhaps the reason I'm so receptive to certain images is that my scholarly problems are more or less existential problems for me and there is no real gap between my life as a primitive individual and the problems I'm dealing with.

This propensity toward self-reflection in the historian's work is representative of the ways many of the social scientists we interviewed discussed the decision making involved in their research. We have previously discussed the relation between cognitive dispositions and artistic modes of knowing. The argument applies here as well: Placing one's self within one's work and blurring the boundaries between work and self involves imagination and awareness of relationships between nuances and gestures of self, research, and human experience. Becoming a reflective practitioner (Schön, 1983) involves not only reflection on one's work and one's self, but also, as evidenced through our interviews, reflection on the relation of one's work to the self.

These social scientists may be highlighting certain experiences or memories while downplaying other important but seemingly nonrelevant experiences in their personal histories in order to create a coherent story of a strong identity with their respective fields. Nevertheless, these highlighted experiences should not be discarded; recollected memories that serve to create a coherent, continuous story of domain identification only emphasize further the importance of such identification.

Identity, the blurred boundary between self in relation to work, is an important one; indeed, in the next section of the paper, it will be seen that such a fundamental and enduring relationship that exists between these individuals and their work is an essential source of motivation and of aesthetic experience.

From our interviews we identify four major sources of motivation that we believe are related to aesthetic forms of experience. These are: the quest for sensory experience; the process of inquiry; satisfaction secured in pursuing fundamental questions; and the influences of colleagues and conferences. Below are examples that serve to illuminate these four sources.

As in any work of art, the work of science has the potential for aesthetic forms of experience because aesthetic experience is inherent in the skilled use of the tools of the trade. An appreciation of the physical properties of data, the manipulation of data or materials, and the organization of data also carry with them a heightened sensory experience for some. For example, one physicist discussed the aesthetic appeal of soldering because he found the flow of the liquid to be a satisfying sensory experience.

- Physicist:* I liked the act of figuring out how materials behaved, and therefore strategizing to make them behave in ways that I wanted to make them behave. I like soldering because of the way the liquid flowed.
- Interviewer:* So, it sounds like there is a kind of physicality; a materiality, a kinesthetic touch and vision and smell.
- Physicist:* I'm not sure how intellectualized it was. It certainly was an appreciation of physical materials and their properties.

The process of inquiry into fundamental questions can also be a source of aesthetic experience. Capturing the essence of a particular discipline by delving into its basic and foundational issues seems, in particular, to have an aesthetic appeal to social scientists. A physicist explained it in this way: "Probably everybody has a sense of some things that are more fundamental and enduring. Physics is a beautiful place for that, really, I mean that is a place where that aesthetic just plays out. Because you're after how the universe works, right? And you're after the bottom level."

Understanding the solution to a problem can be as satisfying as the inquiry process itself. When there is pleasure in intellectualizing a problem, aesthetic experience is possible. This heightened sense of pleasure occurs with discovery or revelation. When reflecting on her inquiry into links between teacher training and student achievement as measured by standardized tests, which had proven to be statistically significant, one educational policymaker exclaimed:

So, it is just like an incredible finding. And it is exactly what I expected and, of course, on some level hoped for. But there it is. Well, what a rush! Maybe it is the human condition to be very happy when your presumptions are proved to be true. But also, I know that I have yet another tool, another piece of ammunition, another piece of work that many people are eager to have because they're fighting battles out there in Washington and in the State houses.

The pursuit of fundamental questions is also an important source of satisfaction and motivation for nearly all the social scientists we interviewed. Uncovering the mystery, capturing that which seems elusive or ineffable, and pursuing deep understanding is a nonlinear process, and

sometimes even unanswerable in one's lifetime. As one historian stated: "I'm trying to do something which is not so obvious. I know that on the one hand, this is a luxury, because it might be a complete waste of time."

Pursuing fundamental questions poses a tension between risk and safety. Because such questions are often unanswerable or cannot be fully resolved in one's lifetime, there is a risk of trying something that won't work, or doubting one's direction, experimentation, or theory. To stick with the metaphor of a journey, there is no well-worn path to follow, only a landscape to be discovered and explored. Sentiments such as, "you're committed to something that will last for a long time, even if you can't get there" are followed with sentiments such as, "going after fundamental questions is a risk, but it has a kind of security."¹⁴

The three motivational factors mentioned above—the satisfactions of sensory experience, the aesthetic experience of inquiry, and the pursuit of and satisfaction secured by exploring fundamental questions replete with risk and safety—are all important internal motivators in some sense. But outside forces play an important role in motivation as well. A psychologist says, "There is also an existential part [that] is always there; you are pushed to apply for new research money and you are pushed to write articles, you are pushed to go to conferences."¹⁵ Deadlines, conferences, meetings with colleagues, publication—all of these forums make public the internal conceptualizations and private tinkering of the social scientist. Colleagues provide valuable feedback and a testing ground for ideas, often driving research and inquiry further. While not all outside pressures are viewed as positive, many of these inspire new ideas and stimulate research born of informed criticism, public response and receptivity, and collegial competition.

We turn now to the use of mental models—visualizations—through which social scientists reflect on their work, in this case the work of a clinical psychologist who does her research on competition. During the course of an interview she mentions the importance of models in her work.

This model I have in my mind is a kind of dynamic model. It is not something that is motionless. I have it in my mind and whenever I read something, whenever I read descriptions of students about competition, I have this model in mind and if things fit into the model, I just notice it. But if I cannot put together what I get from my results and the model, then I try to figure out what I can change in the model; what do I have to change in it? Do I have to change something in the model? Do I have to enrich the model or make it more complex? Or maybe I don't understand what is going on here. For example, what I am doing now.

You try to look at it, O.K. I have a model of personality, competitive personality. Then what kind of competitive personalities exist? Are there as many competitive types of people as the number of people, you see? Or are there typical patterns, and you have a kind of finite number of groups of people who can be categorized into one group.

Say this is this type of competitor, and this is that type of competition and that is that type of competition. Then if you reduce the number of types you can look for their development. And then you can find out how does this develop. What kind of family does it take? What kind of socialization process does it take? Then

you can think of it in another way. This is where they come from, this is where they go. How can you credit their behavior in a certain situation? What can you expect?

So then this is the way of thinking I do and I try to set up a kind of model about the personality side of it. But this personality question, this is one type of a much bigger model that tries to contain socio-biological approaches, tries to contain gender approaches, tries to contain cultural—I also mean religious, for instance—and what kind of nationality that person has, and also socioeconomic factors.

What comes through from her comments is the heuristic value of the models she creates for raising what might be called, “telling questions.” Her ability to visualize and to treat her visualizations flexibly, to modify them over time, feed the formation and realization of her research purposes. Furthermore, these models constitute a framework for the interpretation of what she reads. Her sense making is significantly influenced by the features of her dynamic model.

We have already suggested why we believe visual models provide cognitive advantages. Models are synchronic in structure. Using models, relationships can be displayed that cannot be displayed as well in diachronic material. We are more apt to notice these relationships, as we do in looking at a map more so than when we get verbal or written descriptions of the same phenomena. Pictures work. What does it take to be able to construct such pictures? What kind of dispositions and cognitive skills are needed? Imagination is also at work; indeed, what else would we mean by imagination if not the ability to generate images that we ourselves have created? Is this a case of artistry at work? We think so. And if it is, what implications does it have for the kind of cognitive processes we cultivate in schools, not only in the study of science, but in other fields as well?

Models are not the only heuristic that help social scientists do their work. Another heuristic is empathy. One clinical psychologist was asked, “Are there other parts of the process of helping you figure it out? You mentioned that this was just one part of something you do to help you figure it out.”

What else helps me figure it out . . . there is another approach to understanding. There is a kind of empathy. To put myself into that person’s position and to try to understand. So that’s another process and it is at an emotional level and I use my imagination. I imagine how those ideas come, and what kind of emotional significance, for instance competition can have for that person. That’s a very different thing: this is rather emotional. This is rather, when I draw it, rather a kind of logical process. So I’m trying to find the logic in something. When we use empathy, then it’s a kind of emotional understanding. It’s not a logical process at all.¹⁶

Models and empathy. A visual structure displayed in the mind’s eye and the emotional experience secured by being able to put yourself in the shoes of another and by doing so to “know” what the other is undergoing. It seems apparent that both these processes feed cognitive understanding even though neither may be completely translatable into linguistic equivalents.

To summarize, the work of science provides an arena for aesthetic forms of experience. Aesthetic experience can be secured in the use of the tools

of the trade, in shaping one's thoughts, and in exploring one's ideas. These social scientists are motivated by both the outcomes or end-products of their work and by the quality of experience generated by the process. The experience of doing research is consummatory: they seem to find joy in both the journey and the destination. They also enjoy coming in first.

IV

In the introduction to our article, we discussed the widely held conception of the public side of science as the pursuit of knowledge, a process concerned with technical, rational, and logical procedures, ideational outcomes, and products. Our study addresses the personal side of science, focusing on the experiential processes of scientific investigation with specific reference to aesthetic or artistic aspects of research in the social sciences, that is, we wanted to know about scientific research as experience characterized by surprise, uncertainty, joy, and satisfaction in the process of doing science.

In closing our article, we revisit and distill the salient features of the personal side of science and discuss the educational implications that may be drawn from our research. The social scientists interviewed for our study often spoke of or alluded to using imagination frequently in their writing, conceptualization, and analysis. Imagination is an elusive term. How can one describe unseen and often nonverbal thoughts? The use of imagination can be understood through their remarks about visualization, audition, and the employment of metaphor as ways to deepen understanding. For example, recall that when the policy analyst we interviewed above spoke of her writing, she spoke about her mental conceptualization as similar to creating music. Hearing words as music and extending the auditory experience of writing to musical composition goes beyond colorful, metaphoric descriptions of a process.

Music, like language, unfolds diachronically; it is sometimes the equivalent of a narrative, with a beginning, thematic development, climax, and conclusion. But the auditory experience of music is different from language in that it is organized synchronically as well, that is, a harmonic structure allows us to comprehend simultaneously the relationship of congruent parts (and sometimes incongruent parts) to a larger whole. Trying to hear five speakers at once is nearly impossible; one has to tune out other voices in order to follow the voice and meaning of one speaker. But in a musical form such as a fugue, the different voices are coordinated so that one is able to comprehend all the voices together. Describing the process of writing as similar to musical composition is not accidental; it points to a particular form of cognition that is essential to the working out of an empirical scientific problem.

Many other social scientists spoke of visualizing a conceptual scheme or graphically designing a system in order to see the relationship between the parts and the whole. In a visual scheme, relationships are synchronic.

Visual representations allow for a simultaneous examination of parts to a whole upon which their relationships can be immediately understood and contemplated (Tufte, 1997). Visualization is also a particular form of cognition, one that seems essential for working out conceptual frameworks, relationships among data, or the analysis and writing up of results.

Visualization, audition, and the use of metaphor are all aspects of imagination that are employed by the social scientists we interviewed. But does this mean that the use of imagination is an artistic endeavor? If artistry involves judgments about the relationships of material in terms of rightness of fit, and if such judgments involve attention to nuances such as choosing exactly the right word to describe a process or relationship among elements, then artistry is present in the work of these scientists.

A second feature of art in science concerns somatic forms of knowledge. Somatic knowledge involves using the physical body as a source of information. This might involve understanding the sensuous qualities of the materials with which one works, as well as making a decision because it feels right. Such judgments may be ineffable and thus difficult to explain and articulate. However, the social scientists we interviewed articulated moments in which reasoning through sensory qualities played an important role in working with concepts and materials. An appreciation of the physical properties of data, the manipulation of data or materials, and the organization of data have the potential to generate a heightened sensory and emotional experience. For example, the cognitive scientist we interviewed talked about the tangible and sensory qualities of soldering: He liked the act of figuring out how the materials behaved, and therefore strategized to make them behave in ways that he wanted them to behave.

There are many instances of somatic knowledge revealed through the interviews. The use of objects such as pictures or actual artifacts, or of being in an environment in which the physical materials situate the physical body, aid scientists in their understanding of particular phenomena. The policy analyst and historian both spoke about using photographs as a way to understand the dynamics of events. The biologist who studies dolphins spoke about the sensuous qualities of the physical landscape, the ocean, and the animals themselves as a way to understand the broader environmental context in which these animals live.

In the Western, Cartesian view of cognition, the mind and body are considered separate; thinking belongs to the domain of the mind, not to the body. Our study illuminates the critical component of knowledge gained through physical understanding. Cognition is not just about reasoning through word or number; it is about using one's senses and the sensuous qualities of materials to think within a medium, of physically engaging with the world, in order to reason. Similar to the ways an artist uses the materials of his or her medium, a scientist is guided by the sensuous properties of materials and makes choices and judgments that are based on somatic knowledge.

A third feature of artistry in science concerns empathic knowledge, an understanding of and identification with another's emotions, experiences,

and motivations, or the attribution of one's feelings to an object. Nearly all the scientists interviewed spoke about placing themselves in the position of another person, drawing on one's personal experiences in order to understand the motives of others or to understand the meanings of objects. A strong identity with their domain of work, as described in the body of the article, may also contribute to empathic knowledge. Examples of empathy vary according to the materials with which a scientist works. The historian explained that his receptivity to historical images and events is due to the blurred nature of the existential problems he investigates in his own life. Similarly, the archaeologist connected her own life with the artifacts she was exploring in order to draw her conclusions about the changing nature of cooking and women's roles under Aztec conquest. Recall that the psychologist uses empathy as a way to make sense of her work: "There is another approach to understanding. There is a kind of empathy."

Empathic reasoning and knowledge are different, though not necessarily separate, from other types of cognitive processes such as logical reasoning or mathematical deduction. It is a knowledge based in emotional connection and identification with a subject or object that is deep enough to stir feelings of understanding. Empathy can lead to imagination, and imagination may lead to complex outcomes or insightful solutions.

Is empathic knowledge an artistic feature of cognition? While empathy may not solely lie in the domain of artistry, emotional experiences are usually relegated to the arts; indeed, this view of the arts as emotional is so pervasive that it is a stereotype. Empathy is often employed by performance artists. Actors often draw upon their own experiences to render a character, or do extensive research on historical characters in order to know and understand a character. In the age of postmodern art, visual artists, dancers, and musicians use empathy in conceptualizing an art form that will intentionally provoke certain emotional responses in an audience, such as the use of everyday objects, or through actions that will provoke an audience to confront sociopolitical issues. The social scientists we interviewed reveal the salient role that emotions play in thinking through scientific research.

A fourth feature of artistry in science concerns creating a sense of place, or nest building. We spoke earlier of the interaction of culture and cognition, the importance of creating both a physical and cognitive environment for research and writing. From the biologist who discusses the aesthetic features of her environment, to the sociologist who ritualizes his writing with music and juice, to the psychotherapist who uses mental warm-ups before she writes, a concern with the aesthetic properties conducive to thinking and doing, however simple or complex such aesthetic properties might be, is present in the work of these scientists. Such aspects of the researcher's experience can be considered artistic, especially as these rituals and habits build over time and lead to competence in one's field.

A fifth and final feature concerns the sociocultural influences of motivation, mainly in the area of competition. Not only were these researchers motivated by internal sources of satisfaction, such as the pursuit of funda-

mental questions, they were also motivated by their colleagues, the direction of their field of study, current paradigms, and the urge to arrive at new understandings of phenomena. Colleagues play an important role in two senses: they provide a supportive network and critical forum, and they provide generative competition. Indeed, these scientists spoke of getting there first as a major source of satisfaction accompanied with a heightened sense of feeling a rush. The feelings that accompany such a pursuit of knowledge are not only joy and excitement, they also include fear and doubt. But, as mentioned above, this interplay between risk and safety creates the aesthetic and emotional dynamic that is so motivating to these researchers.

These five features: imagination, somatic knowledge, empathic knowledge, nest building, and the sociocultural influences on motivation, are major themes in our interviews and mark both artistic modes of thought and aesthetic forms of experience. But what do these themes mean for education? What are the educational implications of our research? It is this question to which we now turn our attention.

V

The education of scientists has largely ignored qualitative features or forms of cognition relating to artistry in scientific research. Currently, our schools and universities teach with a limited view of cognition, one that is often positivistic, goal-driven, and outcome-oriented.¹⁷ Our school assessment schemes reflect this: we value the right answer, quick solutions, and close-ended systems of meaning wherein students have to aspire to predetermined standards. But if we take other forms of cognition seriously, such as the forms present in artistry, our vision of schooling and teaching might change. Just as we advocate the personal side of science, schools might advocate the personal side of education. One way schools might change is to provide activities and experiences that allow for the use of imagination, somatic knowledge, and empathic knowledge. Such activities would be open-ended. Students would be allowed to explore and experiment with possibilities, draw on personal information and experience, and use a variety of media with which to explore ideas. In this view of teaching, curriculum, and assessment, multiple truths are possible, and multiple ways of knowing are encouraged.

The researchers we interviewed spoke about the *process* of science, as well as the *products*. Some labor for years, manipulating data, researching related methodology, trying out different conceptual frameworks, before they ever reach a conclusion. These experiences are consummatory; the joy is in the journey itself. If schools value consummatory educational experiences, then a curriculum lesson might linger a while; rather than covering a subject, students and teachers might tarry in order to uncover it, probe the possibilities that are there, and discover the surprises, as well as the disappointments, inherent in any journey.

A second implication that our study carries for schools concerns the creation of a physical and cognitive environment that fosters productive educational growth and the nest building or sense of place of which the social scientists spoke. It has been said that schools are places with very few soft surfaces. School buildings are often of institutional design without concern for aesthetic features that might be conducive to learning. If it seems inappropriate to consider the importance of an aesthetic environment for learning, consider what might happen to cognition in an *anesthetic* school environment, a place where metal detectors, hall monitors, and law enforcement officials greet students every day in some schools. Is such an environment a place that inspires and nurtures or a place that imprisons and monitors?

Recent ethnographic studies on the connection between place and person, in which a physical place constrains, constitutes, and connotes certain types of experiences and thought, reveal the complex interaction of one's physical environment with cognition (Basso, 1996; Feld & Basso, 1996). Similar to the recent research on the interaction of culture and mind, physical and mental environments constitute each other. In short, then, it can be argued that the environment of a school, which includes physical, aesthetic, and cultural dimensions, matters significantly in the creation of young minds.

What might a school that fosters aesthetic and artistic features of learning look like? The rearrangement of physical space to provide or encourage interaction among peers or to encourage the use of floor or wall space for student projects, or decorating classroom and school walls with student art and projects are perhaps an obvious examples. Less obvious, perhaps, is the rearrangement of curriculum and assessment, both of which physically manifest themselves in the classroom and are directly related to cognition. A curriculum that promotes aesthetic and artistic modes of thought would include opportunities for open-ended exploration, projects that engage students' imagination, experimentation, and judgment, and different media with which students can explore and test their ideas.

Such curricula need not be concerned exclusively with art. As our interviews with the social scientists reveal, science, history, and social studies curricula can be taught in ways that are authentic to the ways social scientists work. Critical to this authenticity are activities that allow students to gain a feel for the medium, a somatic knowledge of the materials that would guide them in nuanced exploration and problem solving. In addition, providing diverse materials and resources authentic to the work that historians, scientists, or writers do could support such an environment.

An important feature of establishing an environment for artistic and aesthetic modes of thinking is to build in opportunities for reflection, or metacognition: "taking advantage of your own teachable moments" as one social scientist explained. Much has been written about metacognition and reflection in the classroom, but little research has fully addressed the implications and importance of such cognitive activities. Our study of social scientists reveals that a formative style of assessment is clearly evident in the

real-life work of social scientists; indeed, many of their aesthetic experiences occur during reflection or meta-analysis, when they are able to find patterns, link their data with other supporting data, or use a tried and true cognitive or physical strategy to aid them in figuring out a problem. Metacognition, in other words, happens in the real world of adult professionals as an important part of working through a problem or a task, allowing for such important feeling states as empathy and imagination as well as logical and rational reasoning. If such thinking is critical to the work of adults, perhaps metacognition should be valued in schools. Providing a structure in which students reflect on what they have discovered, think of questions that they might have for further steps in the inquiry process, and process their insights into their own ways of thinking is a critical step toward educating students to think like good scientists, historians, or biologists.

This view of assessment is radically different from the forms of assessment that inhabit schools. Assessment practices often are either separate or decontextualized from the immediate context of learning, or they are summative, arriving at the end of the unit, term, or project. Our study of social scientists suggests that schools should view assessment as embedded in and indistinguishable from curriculum so that it is valued as an episode of learning (Wolf, 1987/1988) rather than as an add-on. Embedded assessment offers opportunities for understanding that are critical to the pursuit of knowledge both in and out of school.

A final implication of our research concerns the sociocultural aspects of motivation. Motivation is typically not linked to the aesthetic or the artistic; yet, our interviews reveal two intriguing, and at first glance, somewhat contrasting sources for motivation. As our interviews reveal, competing to get there first can be an important aesthetic experience that motivates inquiry into a field of study. Competition in our educational system already exists and is often viewed as pejorative. Our societal notion of competition is comprised of individualization and differentiation, and schools are no different in their beliefs. Indeed, starting with the progressive era, assessments and classroom practices have encouraged and sustained differentiation, comparison, and normalization, all features that place students in competitive situations. Students learn about such stratification early on: reading and math ability grouping, advanced placement courses, class rank, grade point averages. Implicit in such rankings is the notion that students compete for the best ability groups, the upper tracks, and the best grades. Such competition is inherently divisive.

Competition, as it has been discussed in this article, looks quite different. As the psychotherapist we interviewed indicates in her research on the topic, competition is not necessarily divisive; indeed, it can be a positive motivational factor. Social scientists participate in a field of research and expertise, and everyone benefits from new insights and discoveries. While the race to be first can be viewed as individual advancement, the disciplinary field as a whole is advanced from such contributions. Rarely is this the case with competition in schools and

classrooms; an individual who gets an A or moves into a college preparatory track is not contributing to the advancement of others, just himself or herself. The view of competition presented in our study can be thought of as *contributive competition*.

A second source of motivation, one that is related to this notion of contributive competition, is the ongoing support and critical feedback of colleagues. As several of the social scientists discussed, developing and sustaining forums for discussion of recent issues and advancements, as well as for discussion of their own work, is an important and often inspiring source of motivation. Being a social scientist means participating in a community of professionals who have both similarly and uniquely informed perspectives. Checking one's work with other colleagues yields fresh insights and new considerations for refinement.

If we take the notions of contributive competition and critical friends seriously, what would these sources of motivation look like in schools? In much the same way as social scientists participate in a community of practice, students enter into a community of learners. Unlike adult professions, however, school environments are not necessarily organized around the idea that students themselves can be important sources of motivation for other students. School subject matter provides one key entry point into organizing like-minded cohorts. Positive motivational features might involve the creation of student cohorts around subjects or themes, wherein students look closely at each other's work, develop methods of and criteria for assessment, and give generative critique and feedback.

We began our article with the commonly held belief that art and science are dichotomous. We close our article with a statement about the intimate relationship between art and science. As we see it, the art in science inspires, motivates, and enriches the pursuit of inquiry; indeed, for good work to be done, artistry appears inevitable. While our study is about social scientists, we have suggested that artistic modes of thought and aesthetic experiences are essential to the development of students. Can we think about education as a process aimed at preparing artists? Perhaps it is fitting to end with a response to this question, one given by the British philosopher, art historian, and poet, Sir Herbert Read. Writing in *Education Through Art* (1943), he makes the following statement about the relationship of art to education.

Education is the fostering of growth, but apart from physical maturation, growth is only made apparent in expression—in audible or visible signs and symbols. Education may therefore be defined as the cultivation of modes of expression—it is teaching children and adults how to make sounds, images, movements, tools and utensils. A man who can make good sounds, he is a good speaker, a good musician, a good poet; if good movements, a good dancer or laborer; if good tools or utensils, a good craftsman. All faculties, of thought, logic, memory, sensibility and intellect, are involved in such processes, and no aspect of education is excluded in such processes. And they are all processes which involve art, for art is nothing but the good making of sounds, images, etc. The aim of education is therefore the creation of artists—of people efficient in the various modes of expression. (p. 11)

NOTES

1. The distinction between the aesthetic and the artistic represents an emphasis on appreciation as contrasted with creation. However, in a Deweyan framework, appreciation is itself a creative activity.
2. For a philosophical treatment of what is ineffable, see Polanyi (1966).
3. The idea that one can reason with feeling is oxymoronic; reasoning is almost always restricted to linguistic forms of cognitive mediation. We believe this conception is utterly unjustified. Choices and judgments about matters of quality are expressions of reasoning within the qualitative domain. The results of such reasoning are epitomized in works of art.
4. Since scientific inquiry is regarded as representing the apotheosis of cognition, illuminating its feelingful features is one way to widen and deepen our conception of cognition. Thus, the deep reason for this study.
5. For further discussion, see Goodman (1968).
6. See Tufte (1997).
7. Her comments underscore the importance of sonority in the organization of both speech and written material. People with tin ears do not make good writers. Indeed, the decision to use a comma as contrasted with a semi-colon in the context of a sentence is not only due to grammatical rules, but to what the sentence calls for from an aesthetic perspective.
8. The observations of the student of dolphin behavior and the sociologist underscore the sources of aesthetic gratification in the context of doing research. Those sources are far wider than the particular decisions one might make on the research project itself. In these instances they include the selection or creation of an environment that is comfortable or deeply satisfying. It seems to us that such considerations matter in thinking about why people do research and how aesthetic matters contribute to it.
9. The importance of surprise as a motivator for research is a repeated theme in our interviews. Surprise connotes an opportunity to learn, which, of course, is the ultimate aim of research.
10. It is significant, we think, that some researchers have learned to create the personal conditions that allow them to enter another state or to exploit an event that promotes their research activity. Researchers sometimes put themselves in states of mind that are conducive to their work.
11. A feeling for the medium shares similarities to a feeling for the organism. See McClintock (1987).
12. Early childhood experiences appear to shape identities that continue throughout life. This is the case with "Mr. Scientist," as it is with the influence of parents on the child's conception of self.
13. This response provides another example of early childhood influences.
14. What we see here are research scientists interested in going after "big fish," often with great risk as well as great reward.
15. Motivation not only emanates from an internal locus, it is promoted and stimulated by the social context within which social scientists must do their work. This is especially acute in universities where matters of tenure need to be addressed.
16. It is important to note that empathy is regarded by this social scientist as "not a logical process" but more of a somatic process.

17. Currently, the standards and accountability movement in American education has created a relentless emphasis on the attainment of prespecified goals. The focus is almost utterly outcome-oriented with relatively little attention paid to matters of process.

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