An Aesthetic (Deweyan) Perspective on Science Learning: Case Studies of Three Fourth Graders

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Abstract

After a critique of two popular and current perspectives on the nature of understanding in science education (learning as change in conceptual understanding and learning as change in discourse and participation with others), we offer our own competing perspective drawing from Dewey, aesthetics, and aesthetic experience. We believe complex learning is best viewed as a dialogic process between person, world, and socio-cultural context that ends in a rich network of knowledge combined with a deep appreciation for the beauty and power of subject matter that transform one’s perceptions of the world and of her/himself as knower. We use our perspective, that of aesthetic understanding, as an analytic lens to critique and illuminate the learning of three students studying geology in a fourth-grade classroom.

The world looks so different after learning science. For example, trees are made of air, primarily. When they are burned, they go back to air, and in the flaming heat is released the flaming heat of the sun which was bound in to convert the air into tree. And in the ash is the small remnant of the part which did not come from air, that came from the solid earth, instead. These are beautiful things, and the content of science is wonderfully full of them. They are very inspiring, and they can be used to inspire others. (Richard Feynman, as cited in National Academy of Science, 1995)

We believe understanding is not most often driven by practical or instrumental purposes. The desire for understanding is driven by something more human. It is people’s nature to seek connections—connections to others, to the earth, and to ideas. This sense of connectedness is not only at the level of individual cognition; it comes
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from a desire to know with one’s heart and mind, emotions and cognitions, imagination and reason. People pursue understanding to feel connected in ways that tell them they are human. As Feynman suggests, people strive to understand for aesthetic reasons.

Many views of learning science are driven by the goal of conceptual understanding. Teachers want their students to have accurate mental models of the way the world operates, to “get it,” if you will. Recently, another goal for science education has become to help students learn to “talk science.” Such discourse-based perspectives argue that science educators should strive to teach students how to inquire, formulate, and argue in ways true to the nature of science. Both of these are worthy goals. However, we will argue that both fall short of another important criterion of success in science learning. Ultimately, education should influence not only how students understand and talk about the world but how they experience (i.e., think, feel, act) it. The arts can educate people in ways few other disciplines can. We believe science can be taught in ways that borrow from aesthetic and artistic pedagogy to tap the power of aesthetic experience. These experiences can be the basis for a powerful, different kind of understanding—esthetic understanding.

To some readers, using the arts as inspiration for science education may seem misguided. Jackson (1998, p. 124), referring to Dewey’s Art as Experience, explains what one can learn from experiences with art: “The arts, above all, teach us something about what it means to undergo an experience. Successful encounters with art objects and performances offer a set of standards by which to judge ordinary experiences.”

We articulate one possible solution to the following question: How can one construe learning in ways that appeal to aesthetic ways of knowing while fostering value in important and powerful curricular ideas? We compare and contrast our perspective to two other popular views of understanding in science education research: learning as change in conceptual understanding (as exemplified in conceptual change theory) and learning as change in discourse and participation with others. Because our theoretical framework is relatively new and, in some ways, radically different from other current science education frameworks, we take the time to develop it more completely than perhaps most research studies.

Three Conceptions of Understanding in Science Learning

Two common and popular views of understanding in science education are conceptual change learning made popular by Posner, Strike, Hewson, and Gertzog’s (1982) widely cited article, “Accommodation of a Scientific Conception: Toward a Theory of Conceptual Change,” and a discourse-based view of understanding as characterized in Lemke’s (1990) influential book Talking Science. We realize that no one work represents the theoretical preference of all researchers in a single paradigm, but we chose these works because they lie at the heart of these two perspectives. Each of these views has garnered much support in the science education research community and has led to considerable research. In order to better understand what we mean by aesthetic understanding and to make a case for its importance, we compare and contrast it to these two important perspectives on learning science. To better understand how these perspectives relate to each other, we organize our discussion around six main questions.

- To what epistemological tenets does the theory subscribe?
- What is the role of the learner?
- What motivates learning?
- What is learned?
- What would be the central curricular organizer in the theory?
- What is the role of the teacher?

We believe these questions address the most substantive issues in a theory of un-
Conceptual Understanding and Conceptual Change Theory

Conceptual understanding and conceptual change theory, at least as we characterize them here, are rooted in Cartesian rationalism and individual cognitive psychology. Research on the power of misconceptions has been taking place for 60 years. It originated in the early work of Piaget, but only in the 1980s did the science education community appropriate misconceptions and conceptual change research. Posner et al. (1982, p. 212) give the best description of the underlying philosophy and intentions of conceptual change theory:

"Our central commitment in this study is that learning is a rational activity. That is learning is fundamentally coming to comprehend and accept ideas because they are seen as intelligible and rational. Learning is thus a kind of inquiry. The student must make judgments on the basis of available evidence. It does not, of course, follow that motivational or affective variables are unimportant to the learning process. The claim that learning is a rational activity is meant to focus attention on what learning is, not what learning depends on. Learning is concerned with ideas, their structure and the evidence for them. It is not simply the acquisition of a set of correct responses, a verbal repertoire or a set of behaviors."

Posner and Strike do not deny that other factors (e.g., emotional, contextual) play an important role in learning but ground their theory in the assumption that learning is a rational activity. As such, learning science is a matter of developing concepts that can be justified as corresponding to the realities of the world. School science is, similarly, a matter of helping students build accurate mental representations of the world based on available evidence.

Conceptual change researchers popularized misconceptions research (Brown & Clement, 1989; Clement, 1982, 1983; McCloskey, 1983; McCloskey, Caramazza, & Green, 1980; Rosnick, 1981) and recognized that students often hold strong yet incorrect ideas about the world. To relinquish these ideas in an attempt to gain more accurate ones is the process of conceptual change and, when successful, the process yields conceptual understanding. In successful conceptual change teaching, students' new conceptions will be "more fruitful" and will more closely resemble the accepted concepts of the discipline. The teacher's job is to provide opportunities for students to see the weaknesses or the inaccuracies in their current conceptions through demonstrations or activities designed to instill cognitive dissonance. These dissonance-creating demonstrations have been called discrepant events—discrepant because what students think will happen does not because their beliefs are based on incorrect ways of knowing (Liem, 1992). The students' role is to scrutinize and modify their science knowledge. Once criteria for conceptual change have been met, students then work to accommodate this new or discrepant knowledge, with their current conceptions producing, if all has gone well, more canonical conceptual understanding.

Discourse-Based Understanding

Discourse-based perspectives, as represented by sociocultural theory, typically view science as culturally, socially, and contextually situated activity. With an appreciation of the "situatedness" of knowledge comes a concomitant concern about issues of power and equity. Rather than extend the myth that science is for the elite, Gallas (1994) argues that discourse-based pedagogy allows "teachers and children to move purposely together toward an inclusive kind of talk about science where everyone is admitted" (p. 3). Gallas (1994) and Lemke (1990) both suggest that learning to "talk" science is an accurate representation of
what the discipline of science is most like: a particular discourse or way of talking. Gal-
las describes her book in this way, “Taken metaphorically, it is about acquiring a dis-
course” (p. 4), the discourse of science.

Learning in a discourse-based science classroom occurs through joint questioning,
rephrasing, defending, hypothesizing, crit-
tiquing, theorizing, and imagining about
science. Student ideas are taken as central
to the class conversation. The direction of
conversation is often dictated entirely by
students, perhaps only occasionally guided
by the teacher. Gradually, students learn
how to more easily and appropriately talk
about science in ways that use science
words and ideas accurately. Simulta-
neously, students begin to feel less alien-
ated by science as their own ideas are taken
as having worth. An occasional problem in
discourse-based classrooms is that ways of
talking often take precedence over the ac-
quision of canonical science knowledge.
However, in the hands of a skilled teacher,
canonical understandings do develop.

The teacher in such a classroom must be
skilled in pedagogy and knowledgeable in
subject matter. Beyond establishing a sup-
portive discourse community, the teacher
must recognize and subtly guide student
talk toward more fruitful paths of inquiry.
The student role is to share, defend, and cri-
tique science ideas along with the teacher
and classmates. Learning in a discourse-
based classroom takes a great deal of time
and practice. Lemke (1990) offers an entire
chapter on changing teaching strategies so
that students learn more effectively through
discourse. Students feel motivated to learn
because their identity and efficacy beliefs
about science develop as their ideas are val-
idated and taken seriously. Also, the social
qualities of learning are attractive to stu-
dents.

Successful learning in a discourse-based
classroom is challenging. These words from
Bakhtin (1990, pp. 293–294) eloquently de-
scribe both the idea that to learn is to learn
language and the difficulties of learning a new
discourse.

[The word] becomes “one’s own” only
when the speaker populates it with his
own intention, his own accent, when he
appropriates the word, adapting it to his
own semantic and expressive intention.
Prior to this moment of appropriation the
word . . . exists in other people’s mouths,
in other people’s contexts, serving other
people’s intentions: it is from there that
one must take the word, and make it
one’s own. And not all words for just
anyone submit equally easily to this ap-
propriation, to this seizure and transfor-
mation into private property: many
words stubbornly resist, others remain
alien, sound foreign in the mouth of the
one who appropriated them and who
now speaks them; they cannot be assim-
ilated into his context and fall out of it; it
is as if they put themselves in quotation
marks against the will of the speaker.
Language is not a neutral medium that
passes freely and easily into the private
property of the speaker’s intentions; it is
populated—overpopulated—with the
intentions of others. Expropriating it,
forcing it to submit to one’s own inten-
tions and accents, is a difficult and com-
plicated process.

According to Lemke (1990) and others,
discourse-based understanding includes
two main components: (1) acquisition of
thematic patterns and (2) appropriation of
elements of identity as associated with sci-
ence, science ideas, and scientific commu-
nity. Thematic patterns can be divided fur-
ther into two processes. The first involves
learning the organizational patterns appro-
priate to particular science discourses,
meaning, the kinds of questions to consider,
the evidence that will be persuasive, and
something of the logic necessary to make
compelling claims from existing warrants.
The second consists of learning the partic-
ular semantic patterns necessary to string
together science words in ways that make
sense.

Identity acquisition includes imagining
possible “future selves” (Markus & Nurius,
Dewey's View of Learning

Dewey's ideas about knowledge and learning, particularly his more mature views developed in *Experience and Nature* (1929) and *Art as Experience* (1934), are the foundation for this analysis and the development of our perspective on aesthetic understanding. Dewey would probably acknowledge that learning science's concepts and appropriating its discourse are important features of effective science education. However, he would go on to emphasize that these elements are subsumed in the broader goal of education—to help students lead lives rich in worthwhile experiences. The task of school is to provide students with transformative experiences: experiences that are valuable in themselves and in their potential to lead to other worthwhile experiences.

Dewey's emphasis on experience needs elaboration, for he gives the term important, but easily overlooked, nuance. What does Dewey mean by experience, particularly educative experience? The potential for educative experience often arises in the course of living. However, the experience frequently ends without ever developing. The "inchoate" experience remains embryonic and never comes to mean anything because one is distracted, tired, or lazy. Thus, although there is activity—that is, things happening over time—there is no coherence, development, or flow to these things. Such is the nature of ordinary experience. Dewey (1934, p. 35) contrasts ordinary experience with what he alternately calls educative experience, aesthetic experience, or simply, an experience:

In contrast with such experience, we have an experience when the material experienced runs its course to fulfillment. Then and then only is it integrated within and demarcated in the general stream of experience from other experiences. A piece of work is finished in a way that is satisfactory; a problem receives its solution; a game is played through; a situation, whether that of eating a meal, playing a game of chess, carrying on a conversation, writing a book, or taking part in a political campaign, is so rounded out that its close is a consummation and not a cessation. Such an experience is a whole and carries with it its own individualizing quality and self-sufficiency. It is an experience.

When material experienced "runs its course to fulfillment," Dewey emphasizes that educative experiences become more than events that merely happen. Instead, the forward movement of an experience has a unity among its elements: "Every successive part flows freely, without seam and without unfilled blanks, into what ensues" (Dewey, 1934, p. 36). Furthermore, in these experiences there is a sense of what could be, an anticipation of how things might come together. As an experience becomes imbued with qualities such as anticipation, development, and unity, it also becomes an act of thinking and meaning. Dewey describes educative experiences as having a plot or history, and pervading dramatic quality. Given how Dewey has characterized the structure, flow, and energy of an experience, we propose that educative experiences can be thought of, indeed they are, dramatic events.

**Drama and anticipation: The motivation for learning.** An important issue to consider when comparing perspectives on learning is what motivates learning. In the discourse-based perspective, the construct of participation is crucial as both the product and motivation for learning. The product of learning, the goal of instruction, is the development of new forms of participation and acquiring the language of a new community. Motivation for learning is charac-
terized by how students respond to their evolving participation—the degree to which they feel able or willing to take on new roles and identities. Dewey would likely applaud the discourse perspective’s attention to identity and participation because it pushes understanding out from inside the head and reconnects it more directly with action and activity. He would likely remark, however, that the discourse perspective’s emphasis on language is an overly narrow interpretation of activity. Language is principally a social phenomenon, an activity between people. Although the study of language is an effective way to appreciate the socially contextualized nature of meaning, it underestimates the importance of interaction with the world of objects and nature. This is a critical shortcoming when the domain of interest is science. For Dewey, an account about what motivates student learning must take into account the interaction of person and world. Indeed, science learning is often a discourse between learner and idea, objects, and experiences in science.

In mainstream cognitive perspectives, such as conceptual change theory, learning is motivated by a desire to reduce perturbations in one’s various representations of the world. Thinking is prompted by disequilibrium or problems. To think is to solve problems (Posner et al., 1982). Dewey’s response to this image of the learner is interesting. Many educators, particularly in the science education community, associate Dewey with inquiry learning, that is, problem-driven learning. Although his earlier work tends to support this view, he modifies his position in his later writing. (The two versions [1910 and 1933] of his How We Think illustrate this development.) Dewey maintains that, although some learning is a response to a particular problem, other learning is an exploration of the possible (Prawat, 1993). In other words, learners get a sense of what might be and are inspired to move forward. Thus, learning not only results in understanding, it is also propelled by it. Dewey (1933, p. 335) clearly describes how ideas precede, rather than follow, inquiry: “There is no mistake more common in schools than ignoring the self-propelling power of an idea. Once it is aroused, an alert mind fairly races along with it. Of itself it carries the student into new fields; it branches out into new ideas as a plant sends forth new shoots.” The drama of anticipation and revelation of the possible animate learning differently than in the conceptual change, problem-driven view.

The accounts of student motivation provided by conceptual change and discourse perspectives, therefore, are incomplete. What is gained from a Deweyan perspective, from seeing educative experiences as dramatic events? To appreciate Dewey’s view of motivation, one must first understand the role of anticipation in dramatic experiences (Dewey, 1934; Jackson, 1998; Prawat, 1993; Wong, Pugh, & the Dewey Ideas Group at Michigan State University, 2001). Consider this example: a person walks down a hallway, approaches a door, and opens the door. This is a mundane description of an ordinary occurrence. It means nothing. By contrast, consider: a person walks to open one of two doors, to encounter immediate pain or pleasure, to make an irreversible choice that will forever change the course of his/her life. This example (a loosely borrowed version of Stockton’s [1907] short story, “The Lady or the Tiger”) is a dramatic event rather than a simple occurrence. What transforms the experience of this event, for either the person opening the door or the person reading the story, from an ordinary experience to a dramatic, aesthetic experience is the powerful feeling of anticipation it evokes. The elements of the event develop and cohere as the individual pushes forward and as the event pulls the individual with it. Similarly, consider science students for whom a science lab is little more than a series of activities to complete. Granted, students are active and there is experience. However, one would be
hard pressed to characterize the lab as an unfolding drama of inquiry where one part leads to the next, where the activity is compelled by the anticipation of what might be. In both examples, the event not only happens but has an energy that connects its parts and moves it forward.

Anticipation is an inherent quality in all-powerful learning experiences. In effective conceptual change or discourse-based science lessons, anticipation is a salient element of students’ experience, though it may not be emphasized in the theory that inspired instruction. Students look forward to the solution of a vexing problem (given that it is meaningful to them), just as they look forward to becoming members of a group.

However, in our view, it is not sufficient to claim that some form of anticipation can be found in students’ experiences in these situations. The conceptual change and discourse perspectives might agree, with indifference, with this observation. Thus, we take the point further by making anticipation itself the heart and substance of worthwhile learning. In other words, when Dewey’s position that education should lead to worthwhile experiences means that schooling should fill students’ lives with anticipation. Now, the difference between Dewey’s views and others’ becomes more distinct and consequential. Not only should students learn concepts and how to talk science, they should look forward to the experience of using and developing concepts and discourse in the real world. They should desire to see where those concepts take them, to see how the concepts might transform their existence in the world. Similarly, students should have some sense of where their newly acquired language might take them and feel an urgency to move in that direction and develop their language further. For Dewey, good teaching initiates and sustains the drama of learning initiated by anticipation.

**Anticipation is aesthetic.** Anticipation both organizes and develops the educative experience and is, therefore, fundamentally intrinsic to this dramatic event. Unlike concepts or language, anticipation does not exist, in any meaningful sense, separately from specific experiences. In this way, it is quintessentially aesthetic in nature. Similarly, the value of concepts and language is typically associated with what is achieved through their use. Conceptual understanding facilitates problem-solving; language enables participation with others. Although Dewey agrees that all educative experiences should be instrumental in this way, he would also maintain that the aesthetic nature of intense experiences infuses them with intrinsic value. Educatively, aesthetic experiences are worthwhile in both themselves and their yield.

To repeat a point made earlier, instruction generated or analyzed from conceptual change or discourse perspectives can have aesthetic qualities. The point we are making is that these important qualities of learning are either less likely to occur or less likely to be noticed when instruction or analysis, respectively, is grounded in these perspectives. To bring out the aesthetic qualities in learning, we propose that science education should be organized around a fundamentally different curricular unit. Rather than understanding concepts or appropriating language, learning science should be about having ideas-based experiences (Pugh, 1999).

**Three Qualities of Aesthetic Understanding**

One strategy for understanding Dewey’s perspective is to compare and contrast it, as we have in the preceding section, to other important views of learning. Another approach to understanding the meaning of ideas is to explore their pragmatic consequences—that is, their effect on the lives of teachers and students. This is our goal in the empirical portion of this article. In order to transform the conceptual ideas of aesthetic understanding to practical activity, we first had to identify and operationalize important qualities of aesthetic understanding.
Then, these qualities formed a framework that guided our approach to teaching and the design of our assessment. Although we acknowledge the complexity of the idea of aesthetic understanding, in the interest of coherence and simplicity, we chose to focus on three important qualities. All aesthetic understanding is dramatic or compelling, transforming, and unifying.

Dramatic or Compelling

Transformative experience is "active and alert commerce" with the world—"commerce" being the forward-moving transaction between testing ideas and undergoing the consequences. The drama of powerful learning comes from the anticipation internal to this process. Dewey's emphasis on ideas and anticipation supercedes the problem-solving mechanism of conceptual change in that learning can be both driven by problems and inspired by possibilities. In addition, Dewey's account gives a prominent place for emotion, the varied feelings of anticipation, in the experience of learning. In contrast to the discourse perspective, subject matter has greater prominence in Dewey's account of what motivates students. In educative experiences, anticipation about testing ideas in the world, rather than social participation, compels students' engagement.

For Dewey, experience is a negotiated process between action and undergoing (being acted upon) that ends in expanded perception. The goal of an experience is to resolve these perceptions into some meaningful, unified experience. Dewey calls "dynamic organization" the process by which people negotiate action and undergoing; the process by which they organize their perceptions and rectify their structures into a coherent whole. "That which distinguishes an experience as aesthetic is conversion of resistance and tensions, of excitations that in themselves are temptations to diversion, into a movement toward an inclusive fulfilling close" (1934, p. 56). People work hard to make their conceptions or experiences "fit," and when they do, understanding becomes aesthetic. "The doing may be energetic, and the undergoing may be acute and intense. But unless they are related to each other to form a whole in perception, the thing done is not fully aesthetic" (p. 50).

Because of this flux, an experience is an emotional state that fuses actions, events, and emotion into a unified whole. This drama and affective unification also provide an aesthetic quality to experience.

It is not possible to separate in a vital experience the practical, emotional, and intellectual from one another and to set the properties of one against the characteristics of the others. The emotional phase binds parts together into a whole; "intellectual" simply names the fact that the experience has meaning; "practical" indicates that the organism is interacting with events and objects that surround it. The most elaborate philosophic or scientific inquiry and the most ambitious industrial or political enterprise has, when its different ingredients constitute an integral experience, aesthetic quality (Dewey, 1934, p. 55).

Dewey believed aesthetic experiences are recursive, not circular, but perhaps spiraling. Rather than coming to a final conclusion, people are compelled to seek other experiences. To "get it" is not to come to rest, as can be connoted by other perspectives. For Dewey, understanding often generates more thinking and more action—even more than the logical problems associated with problem-solving perspectives—as people ask themselves which route to pursue or where and how else might these ideas be useful. We believe aesthetic understanding is not an end state but only a jumping-off point that compels people to learn more.

Students may make statements like the ones below, which would qualify as evidence of the compelling power of experience: "I can't wait to tell others about this!" "I've really been thinking a lot about this." "Learning about this has made me want to learn about other things."

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The compelling nature of experiences can be thought of as facilitating "ideas on the brain." Students who think about ideas, want to talk about them, pursue them in other ways and in other settings, have ideas on the brain, which is an indicator of the compelling, forward-looking nature of experience.

Transforming

Dewey's epistemology highlights how a new entity is created in the dramatic experience of learning. This "event" or "situation" exists only in the transaction of the individual, world, and idea. Dewey's concept of transaction highlights two key features of aesthetic experience. First, it describes how learning can truly have intrinsic value. Other perspectives tend to portray concepts and language as tools or means to an end and, in our opinion, struggle to explain how learning can occur for "its own sake."

Second, Deweyan transaction illuminates how dramatic experiences are transformative. As the individual acts on the world, the world necessarily acts on the individual. Each is influenced and changed by the other. The unfolding of an experience is the mutual development of the individual and world. This mutual transformation as individual and world transact is a key element in Dewey's epistemology. Dewey (1934, p. 39) writes, "Experience does not go on simply inside a person. It does go on there, for it influences the formation of attitudes of desire and purpose. But that is not the whole story. Every genuine experience has an active side which changes in some degree the objective conditions under which experiences are had."

As an example, a friend tells a story about his childhood in which he came to be aware of the idea of adaptation. Suddenly, everywhere he looked he saw evidence of why and how living things survived. He literally "saw" adaptation all around him and was changed by the revealing power of this idea. Neither he nor his world exited this transaction the same. This is the potential of aesthetic experience. Through action, or more specifically, the transaction between individual and world, experience is transformative.

In short, the new relationship between person and world is the "product" of learning. This view contrasts with conceptual change perspectives where individuals' conceptions or representations alter to fit the world. In addition, individuals are changed only to the extent that their understandings change. Dewey describes a change in being—a change in thinking, acting, and feeling.

The discourse perspective describes transformation of identity and participation and, in this regard, resonates with Dewey's emphasis on the whole person. However, discourse perspectives, especially those influenced by the work of Lave and her colleagues (Lave, 1988; Lave & Wenger, 1991), tend to see transformation as a progression toward an established practice. Individuals move from peripheral to more central, more legitimate tasks as they become part of a community of activity. Similarly, learning can be described by the degree to which individuals have appropriated the language of a community such as science. This view of transformation contrasts with Dewey's in two ways. First, as in the conceptual change perspective, there is little discussion of how the learners' worlds are transformed as they develop. Second, instead of convergence toward the conventions of an established group, Deweyan transformation allows for more individuality of experience, often spawning creative leaps and more divergent thought. It seems to us that some account for variation from norms is essential to account for how new ideas and new practices can emerge from established groups.

To operationalize this quality of aesthetic understanding, some examples of statements students may make after a transformative experience are helpful. In reference to a transformed world: "I see the world in a whole new way." "I can't help
but see the idea everywhere now.” In reference to a transformed person: “I feel differently about myself.” “I can see myself continuing to study this.”

Another indicator of transformative experience would occur if a student articulated new opinions, beliefs, or goals for him/herself. For example, Breiana, a student in our study, stated, “I’m thinking about becoming a geologist.” (All names are pseudonyms.) In her telling, she had not previously entertained this idea. Through her engagement with substantive ideas, she was transformed into someone who may become a geologist.

Unifying

In aesthetic experience, learners are drawn forward in anticipation of consummation of an experience. “In contrast with such (ordinary) experience, we have an experience when the material experienced runs its course to fulfillment. [The experience] is so rounded out that its close is a consummation and not a cessation” (Dewey, 1934, p. 35).

Consummation—the coming together of the various parts and incidents, the completion of development—not only marks the end point of an experience but is anticipated through the entire event. To consummate an experience is to see how formerly disparate elements fit together. The coming together of parts is the drama inherent in great art, riveting stories, and engaging scientific inquiry.

For example, in learning about the periodic table of the elements, one comes to understand it as an organized representation of the building blocks of molecules and matter. Learners begin to view relationships between elements and molecules differently. This relationship begins to make more sense, and learners can make predictions based on their knowledge. The periodic table resolves into a more unified representation rather than consisting of disconnected facts to be understood separately. Concurrently, individual elements come into relief. One can speak more accurately and more comprehensively about sodium and chlorine as individual elements because their atomic relationships are better understood.

This quality of emerging unity is not easily detected in discourse perspectives’ accounts of learning outside of group or community unity. Again, however, this is unity associated with participation not subject-matter knowledge. In the conceptual change perspective, in contrast, sense making and connection are intimately related. In the cognitive paradigm, to understand is to make connections. Although both Deweyan and conceptual change perspectives seem to emphasize how learning is unifying, Dewey pushes the idea to the next level. What makes powerful learning fundamentally aesthetic is that it takes on a profoundly moving, spiritual character. Jackson (1998, p. 149) explains: “I think what Dewey means is that it is during those moments of full perception, when we are totally absorbed in what this object or event or idea is like, that the various components of our psychological being—our ability to think, to feel, to appreciate, to experience through all of our senses—come into play at once. At such moments our various capacities not only are realized (i.e., become real) but are also momentarily fused and unified. Only then do we experience what it is like to be fully human.” When ideas engage all our faculties, when we realize greater coherence in our world, when we expand our capacity to think, feel, and act, we experience a kind of transformation of ourselves that is deeply and innately compelling. This is the intrinsic, aesthetic value of educative experience.

Student statements like the following may be evidence of the unifying potential of experience: “This is all starting to fall into place for me.” “The world is beginning to make more sense.” “I get it and it’s so cool!”

Summary

Central to aesthetic understanding is the idea of aesthetic experience. Students learn
through a process of changed perception, a virtual transformation of their world and themselves as they seek to verify ideas. Aesthetic understanding brings unification or coherence to students’ understanding and necessarily moves them out into the world as a result of the intensely compelling nature of experience. What exits aesthetic experience is a more rich, multifaceted understanding that incorporates conceptual knowledge, skills, dispositions, feelings, attitudes, actions, and emotions and value. To value is to see the relative worth, utility, or importance. Value can be placed on an object, skill, or idea in ways that are not necessarily connected to instrumental outcomes. In fact, we argue that instrumental value too often guides teaching and learning. Worth, utility, and importance should be guided instead by aesthetic outcomes—those outcomes that lead to more pleasing or beautiful results. People should not always learn because of what knowledge can do for them, or what it may buy them in the future. The goal of learning should be having aesthetic experiences, coming to aesthetic understanding, and developing value for ideas beyond the purely instrumental.

Table 1 summarizes the three perspectives on science learning.

The Study

The goal of this research was to explore the possibilities of teaching for aesthetic understanding. The first author taught three, 60-minute science lessons per week for 8 weeks (24 lessons total) in a fourth-grade class in a large, midwestern, inner-city school. The class consisted of 24 students, diverse in ethnicity and socioeconomic status but balanced in gender. Student learning was investigated in detail throughout the 8-week period with daily classroom observations, frequent in-class, spontaneous “mini-interviews,” and an extended post-instruction interview conducted by the second author and compiled in field notes. Other data included student-generated artifacts such as written assignments, lab reports, and learner journals, and scores on tests of conceptual understanding. The unit was framed by a compelling, Deweyan idea: rocks have stories to tell. Students learned typical concepts and relationships of a fourth-grade geology unit such as typology of rocks and their relationships through the rock cycle, common names of rocks and their textures, types of weathering that may alter the appearance and cause the gradual destruction of rocks, and basic sedimentation and lithification processes. Each of these concepts, however, was framed in an effort to tell scientifically accurate “rock stories.” Story, as an idea, drove the unit (see Girod, 2000).

This short story from Chloe illustrates a common student-generated rock story: “This is a shale rock. Its depositional environment would be found in a swamp. It is about 200 million years old. It got weathered by water. Water and wind can push it and wash it away. I have some questions. This rock has one end flat and one end has a point because it is a sedimentary rock. It has layers because sediments pack on together to make the rock. It also has holes in it because acid rain was on it.” Chloe’s story demonstrates her ability to answer questions of origin, erosional history, and classification. Although this story is less creative than others, it stands as an adequate representation of a typical rock story.

Teaching for Aesthetic Understanding

Rather than most heavily valuing ways of talking about science or ways of representing science ideas through conceptual models or schemas, the teacher teaching for aesthetic understanding most values new ways of seeing the world—ways that are made possible by metaphors that illuminate powerful science ideas. All three groups of teachers—those who value linguistic or discursive ways of knowing, those who value conceptual or empirical ways of knowing, and those who value aesthetic or metaphorical ways of knowing—want the same thing: for students to believe in accepted, canonical,
TABLE 1. Summary of Three Perspectives on Science Learning

<table>
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<th>Conceptual Understanding via Conceptual Change Theory</th>
<th>Discourse-Based Understanding</th>
<th>Aesthetic Understanding</th>
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<td>What motivates learning</td>
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<td>How learning occurs</td>
<td>Accommodation of new knowledge with prior knowledge; stimulated by cognitive disequilibrium or dissonance</td>
<td>Appropriating language; moving from peripheral to central; participation in a group</td>
</tr>
<tr>
<td>Role of teacher</td>
<td>Help students identify, confront, and replace misconceptions with accepted canonical ways of knowing; emphasis on individual cognitive structures</td>
<td>Help students adopt socially accepted norms or ways of talking about science; scaffold identity development and emphasize community of shared meaning-making</td>
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<tr>
<td>Role of learner</td>
<td>Must recognize misconceptions, then accommodate or replace them with “correct” ideas</td>
<td>Active in constructing and coconstructing knowledge with other students, teacher, and society or culture at large</td>
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scientific ideas about the world. However, the important difference between the third and the first two groups is that teachers teaching for aesthetic understanding hold firmly to the belief that “seeing precedes believing.” This is not a new idea; it was referenced by the forefather of American pragmatism, Charles Sanders Peirce, “The elements of every concept enter into logical thought at the gate of perception” (cited in Pravat, 1999, p. 62). Educators must teach students how to see the world through science ideas before their ways of thinking and speaking conform to canonical understandings. We offer three steps in this regard.

**Step 1: Offer the metaphor (lens).** The most important step in teaching for aesthetic understanding is choosing a lens or metaphor to guide perception. This initial lens or metaphor is used to organize a body of content (a single science idea, a set of related science ideas, a lesson, a series of lessons, a whole unit) in engaging ways. In this case, the lens used to guide perception is that of story—specifically, that rocks have stories that can be interpreted with some understanding of geology.

Once the teacher identifies an appropriate metaphor she must describe it to her class in such a way that produces a sense of wonderment, use of imagination, and consideration of the possible. Wonderment creates anticipation, a quality vital to engagement, inquiry, and deep learning. Anticipation was created in this unit by interpreting stories of various objects, life
histories of people, and eventually the rocks that children brought to class.

A skillful teacher must consciously model the power of the metaphor. The metaphor must be shown to transform the teacher’s own perception, allowing access and understandings of new and interesting aspects of the world. Modeling the power of the metaphor leads to scaffolding students’ attempts to personalize it—to employ it as a perceptual lens on their own terms, in their own world—with their own rocks. Modeling and scaffolding were used extensively in this research.

**Step 2: Unpack the metaphor.** Step two of the pedagogical model might be described broadly as “playing with the metaphor.” The main task here is to investigate where the metaphor works and where it falls short as an adequate and empowering descriptor of the world. Teachers might ask questions such as: What does our metaphor help us to see? What kinds of things are more clearly illuminated because of the metaphor? What kinds of things does our metaphor not help us to see or explain? What could we add to the metaphor to make it more effective or more illuminating? Although this step of the model ought to be guided by the teacher, it is important to allow students to do most of the “work” in “unpacking” or “playing” with the metaphor. It is here where most familiar science concepts move into open analysis.

**Step 3: Formalize the language.** The final step is to formalize the metaphor and metaphoric language into canonical science language. Without formalizing the language, science ideas remain in a metaphorical state. Teachers must help students to make sense of their metaphoric understandings against the more formal language of science as found in textbooks, curriculum guides, and standardized tests. In this research, language was formalized as it became necessary and appropriate. For example, students consistently referred to rocks that came from volcanoes as “volcano rocks,” and this term was replaced with the label “igneous.” What is most useful about the model is that activities can be employed at any step in the model with equal pedagogical value. Activities were designed to help develop student perception, to engage students in “unpacking” of the metaphor, and to formalize science language.

Extensive case studies were written to describe the learning that occurred for each student. Three case studies were chosen to represent a diversity of learner experiences and student characteristics. These cases should not be considered extreme or unusual. They are typical of the range of student experiences and were chosen in that regard. Following the case studies, we use the lenses of both conceptual and discourse-based understanding to critique the experiences of the three students. Finally, we view the case studies through the lens of aesthetic understanding in an attempt to investigate the strengths and weaknesses of all three perspectives.

**Three Learners**

**Case 1: Brieana.** Brieana was a vivacious and bubbly green-eyed African-American 10-year-old. She read well for her age and performed at grade level in other areas. The classroom teacher ranked her as typically a B student. Before the unit began, Brieana mentioned she had been collecting rocks for some time already. In fact, she claimed to have about 100 rocks in boxes under her bed. On a pretest of conceptual understanding, Brieana scored 35% (class mean = 28%). From the first day of the unit, she asked questions that pushed her conceptual understanding, and she scored 84% on the unit posttest (class mean = 77%).

Rocks and their stories had a profound effect on Brieana’s perception of herself and the world. In an interview she stated, “I think about the rocks I have differently than I did before. Now, when I don’t have anything to do, I look at a rock and try to tell its story. I think about where it came from, where it formed, where it’s been, what its name is.” When pushed to wonder if other
people thought about rocks the same way she did, she rejected the notion, "Most people think rocks are . . . just junk. Most people think rocks are all the same and not interesting. Most people don’t think about their stories."

Across the course of the unit Brieana expressed growing interest and insight into what rock stories might allow her to understand about the world. "I wasn’t all that interested in rocks before, but now I am. I used to pick them up at the beach and throw them in the water. Now, I couldn’t throw all those stories away." Story, as a way to learn about all things, gradually became a more powerful idea for Brieana. "Telling a story is a fun way to learn about stuff." Story grew to become powerful in Brieana’s life. "I’ve been thinking about the number 2. Where did it come from? A guy just didn’t say, ‘Here’s two.’ I want to know about its story. It seems to be important—two shoes make a pair, two ears, two hands, two arches at McDonald’s." Gradually, narrative ways of knowing moved beyond her science class experiences and into other contexts.

Brieana found that telling rock stories did more than transform her world; rock stories changed her self-perception as a learner. She had become the kind of person who could tell rock stories—an activity that not everyone could do. It seemed to have an empowering effect, even to the point of prompting her to imagine herself as a geologist. "I can imagine myself being a geologist. I have this backpack on and wearing this cool safari outfit with this cool hat, and then I pick up rocks, and I have a partner named Moe. And then I go to people’s schools and teach them about rocks." Her developing identity as an apprentice geologist proved powerfully motivating in her efforts to continue learning. "I have to learn the names of all the rocks because I’m thinking about being a geologist."

Brieana cited many examples when her value for the idea of story compelled her to take action outside of class. One of the most telling occurred only 3 weeks into the unit. Brieana related, "Me and Tameka stayed up until 3:30 A.M. Saturday night making a rock book. We made a book called Rocks and Minerals. We wrote down shale, and conglomerate, and igneous, and then we told where they came from." Students had not been asked to make a rock book or even attempt to write rock stories at this point in the unit, but Brieana felt compelled by the enticing power of the idea. She also described several occasions in which she hunted for rocks on her own and with her cousin. She even replicated class experiments outside of class.

Perhaps one reason Brieana had such personally moving experiences with the unit was the degree to which she could imagine her geologist future-self (Markus & Nurius, 1986). For example, on a class assignment, she responded to the question, "How can a geologist tell the story of a rock?" in this way: "Say she finds a rock. She wonders where it came from. She looks at the rock a lot. She thinks about the depositional environment. She sees a swamp. She thinks mudstone. She looks in a book called How to Become a Geologist. She looked at her rock. It wasn’t smooth. It had sharp
edges and it had ins and outs. The weathering was probably a tornado bumping it everywhere. Eureka!” In one interview, Briana offered the most compelling evidence of her new identity affiliation; “I’m going to be a geologist!”

A year after the unit, the first author saw Briana at the store. After they exchanged hugs, Briana informed him that she still had all the rocks she had collected during the unit and that she still enjoyed telling rock stories. About to go their separate ways, she called out and asked with an inquisitive voice, “Do you think it’s alright to kick rocks?” After stifling a chuckle, he assured her that it was. What does her question suggest? What does it say about the degree to which she places value on rocks and their stories?

Case 2: Leo. Leo’s classroom teacher identified him as one of the lowest academic performers in class. He was a poor reader with poor study skills and little inquisitiveness. She also stated clearly that Leo was a significant management problem. He was constantly off-task, bothering students around him, roaming around the room, and had a habit of gently, but repeatedly, kicking the desk in front of him. Despite these issues, Leo had several friends and appeared socially well-adjusted.

Leo did not seem to expect to do well academically. Upon distribution of the unit pretest, students were asked to do their best and were reminded that their scores would have no effect on their grades. Leo worked quietly for about 10 minutes and then turned his test in saying, “I know I didn’t get any right.” To his surprise, Leo did get a few correct, scoring 12% on the pretest (class mean = 28%). Surprising himself again, Leo scored 61% on the posttest (class mean = 77%), a gain of almost 50%. By traditional grading standards, 61% is just above failing, but his progress was important because it demonstrated to Leo that he was capable of learning science ideas.

About 2 weeks into the unit, Leo stated, as he proudly displayed three books, “I checked these out from the library because I wanted to see some more rocks and maybe learn some more about them. I might just look at the pictures.” Later in the morning, the classroom teacher mentioned that she believed those to be the first books Leo had ever checked out from the library.

Leo’s newfound interest in rocks and fossils transformed him into the kind of person who tells rock stories, wondering where rocks came from and why they look the way they do. Leo explained, “I feel different. Before we studied rocks I didn’t use to think about them. Then we did these amazing things like putting rocks in Coca-Cola, vinegar, water . . . and I went home and tried it and it didn’t work. I wanted to show my brother.” Leo was able to articulate several examples of his thinking about rocks and even explained how he wanted to become a geologist. “It is useful to tell rock stories. I feel different. I feel good.” And, “I’m thinking about being a geologist. It feels great. I feel . . . like a geologist.” Leo’s mind seemed to be constantly alive with thoughts of rocks and how he could interact with them. In fact, in one interview, Leo became excited and shouted, “We should celebrate rocks!”

Rocks and rock stories compelled Leo to do, say, and think about things he had not previously thought about. For example, “I never used to think about rocks. Now I think about where they came from and where they cooled.” When asked if telling stories of things was a good way to learn, he said, “Everything got a story to tell. My face got a story. My body came from inside my mom. That box . . . that paper, your camera . . . everything got a story. My shirt, my shirt came from the store!” Leo’s attempts to use story as a way to learn more about the world are interesting. He seemed to know the general narrative format for posing and answering questions, but his questions were often poorly developed and his answers often naive. Leo worked hard, though, to use story as a way to engage in
dialogue about rocks. During a 15-minute segment of an interview, Leo told 11 stories that had something to do with rocks. The stories ranged from short 10-second ones about finding rocks to lengthy 60-second descriptions about others bringing him rocks and what he thought of them.

Leo struggled to develop a rich conceptual understanding but seemed to excel in using rock stories partly because of his imaginative and creative mind. When asked to imagine himself as a molecule swimming in a sea of molten lava, Leo commented on how difficult it was to swim in the hot, dense soup. He relished the idea of rocks being blown out of volcanoes, forming on the bottom of deep oceans, and bumping along the river bottom. As much as Leo gained in the unit, as much improvement as he made, he was considerably behind most of his classmates. Leo's academic struggles seemed to keep him from participating in ways most commonly accepted as academically oriented or in activities that traditionally are recognized as academically valuable. Perhaps his engagement with rock stories was one of the reasons he valued rocks and the idea of story. Leo's words suggest that this value fostered identity and efficacy beliefs in himself as a science learner: "I talked to my mom about rocks. I said, 'Mom, do you know where this rock came from?' And she said 'No,' so I told her, and she asked how I knew, and I told her I learned it at school. I wanted to tell her because usually I didn't tell her much, and it made me feel good."

Case 3: James. James read and wrote considerably above grade level and qualified as gifted in mathematics. He was articulate, had broad interests, and had a richly experiential life. The classroom teacher ranked James as one of the smartest students in the class, having an outstanding attitude, exemplary behavior, and supportive and involved parents. It was no surprise that he scored well on the test of conceptual understanding. Like Briana, James scored 35% on the pretest of conceptual understanding (class mean = 28%) and raised his score to 91% on the posttest (class mean = 77%)—one of the highest scores in the class.

James read carefully, followed directions well, asked good questions, and was thorough in his work. James always answered questions on assignments with complete sentences, showed his work on math problems, and raised his hand before speaking. Across the unit, the class conducted several experiments, and James approached each in the same methodical way. He refused to be hasty, read carefully, and was precise in completing the experiment. When directions were unclear, James asked for help. Many other students rushed through experiments, made several mistakes, trying again and again until they achieved successful results. James's method gave him only one chance—a high standard for any student.

Shortly into the unit, James was asked if he had ever thought about becoming a geologist. He did not even entertain the idea, instead responding eagerly, "I'm going to be a marine archeologist." Such a career choice is impressive at any age but typical for James. He was successful in understanding the ideas in the unit. He quickly identified the critical kinds of questions one should ask when trying to tell a rock story and memorized the relationships between cooling rate, crystal size, and cooling environment that other students struggled with for days.

However, James did not come to appreciate story as an important idea: "Thinking about rock stories is interesting, but I don't really think about rocks differently than I did before. I am sort of interested in rocks and sort of not. I used to look for good rocks to skip, but that's about it. I still do that. Now, I can say what kind of rock it is and even tell my parents about it if they want, but mostly I just skip them." Later, in the same conversation, James made this statement, which suggests the lack of value he placed on the idea of story: "Even if I knew more about string, string still wouldn't be
interesting." James could tell rock stories, knew that the teacher expected him to do so, but was not motivated to consider rocks and their stories outside of class. Rock stories did not seem to have the level of effect on him that they had on Briana and Leo. Although Briana and Leo thought quite differently about rocks after the unit than they had prior to it, James stated plainly, "No, I don't think about rocks differently. I haven't found myself thinking about the stories of rocks. I don't wonder about the stories of things either." Instead, the comments James most frequently made in class demonstrated or illuminated his conceptual understanding. "I talked with my friend about the rock I found—like what it was made of, and where it was found, and how old it was. He asked me questions like what does igneous mean and I told him." In a small-group activity, James rushed through the telling of a rock story, "It's igneous. It's extrusive. It has very small crystals. It's made of lava. It's been weathered." Another student in his group shouted, "Leave some for us, James!"

We spoke with James recently, a year after the unit on rocks, and he said: "Learning about rocks was cool. I remember doing the experiments and learning all the names of the rocks." We asked him if he had reconsidered becoming a geologist, and he responded excitedly as if he had never told us before, "I want to be a marine archeologist!" What James took away from our geology unit was not the idea of story but a series of facts and conceptual relationships. In this way he was successful, but he failed to find an enhanced sense of being or to experience the anticipation of a narrative perspective on the world.

Analysis of the Cases

Briana, Leo, and James differed in the quality and quantity of their learning. Using the lenses of conceptual, discourse-based, and aesthetic understanding, we examine each student closely.

Conceptual understanding. In terms of conceptual change, all three students pro-
gressed (in varying degrees) toward more canonical understandings of rocks and their relationships through the rock cycle. James suggested prior to a lesson on weathering that factors like explosions from hand grenades might be a likely cause of the disintegration of rocks. Similarly, Briana suggested that cars and dinosaurs caused many rocks to break. Both of these naive conceptions suggest that (a) rocks are broken down by traumatic or violent events; (b) rocks are broken in relatively abrupt events rather than through slow, gradual degradation; and (c) rocks degrade mostly as a result of the actions of humans—or in the case of the dinosaur example, some other powerful creature acting deliberately. During the unit, James and Briana came to understand that ordinary and more widespread phenomena like running water and chemical reactions were better suited to explain weathering and erosion of rocks. After the unit, both students were able to provide more scientifically accepted descriptions of the processes of erosion and weathering and their effect on rocks.

Leo's conceptual change was less successful, particularly his attempts to understand the importance of the concept of geological time. In a beginning-of-unit discussion, Leo speculated that most rocks were only about 100 years old—barely older than his grandparents. Although it was a common naive belief before our unit, most other students relinquished this idea after a lesson on geologic time (see Girod, 2000, for details). Leo maintained, in his unit performance test, that the rock in his story was probably 1,000 years old. Although he was progressing in the right direction, Leo did not yet understand conceptually the vastness of geologic time and the likelihood that his rock was probably much, much older.

The result of these multiple progressions toward more canonical understandings of geology concepts can be seen in the scores on pre- and posttests of conceptual understanding. Tests consisted of 10 multiple-
choice, five fill-in-the-blank, and five short-answer questions. Although we did not investigate the degree to which these tests were psychometrically sound, the individual items corresponded directly to this school district's science curriculum goals. Pre- and posttests were identical, designed to investigate learning across the range of the cognitive taxonomy including definitions, simple heuristic understandings (i.e., slow to cool = larger crystals), and complex model-based understanding of the rock cycle. James scored 91% on the posttest, followed closely by Briana, who scored 84%. Leo nearly failed, scoring only 61% on the posttest. By traditional standards James would get an A, Briana a B, and Leo a D (see Table 2).

These scores suggest that perhaps Briana, with her preexisting interest in rocks as illustrated by her extensive rock collection, and James, as his talented and gifted label suggests, started the unit with more exposure, familiarity, and conceptual understanding than Leo. Briana and James began the unit ahead of Leo and exited the unit the same distance ahead of him in conceptual understanding. In fact, Leo began the unit 16% lower than the class average and exited the unit the same 16% below average. Relative to the rest of the class, he gained just as much conceptual knowledge; he simply had a greater initial deficit to overcome. Perhaps the unit ended too early for Leo and a longer unit would have allowed him to "catch up" with his classmates. Similarly, Briana began the unit 7% above the class average and exited the unit still 7% above average, again, gaining nothing relative to the class average; she performed as expected.

James, however, made gains relative to the class—from 7% above the class average on the pretest to 11% above average on the posttest. In this respect, James should be rewarded for growing at a rate in excess of his classmates and Leo and Briana should certainly not be punished for making gains equivalent to the average. What do these numbers suggest? Should Briana and Leo get Cs because they made gains equivalent to the average? Should James get an A or B because his gains were greater than average? One interpretation is that this interpretive framework maintained initial differences in conceptual understanding, thereby contributing to the status quo.

**Discourse-based understanding.** Briana clearly understood the organizational patterns used to construct and tell rock stories. She knew the questions to ask, the kinds of answers that would be acceptable, and the basic "framework" for telling a rock story. What Briana lacked was a well-developed understanding of the semantic patterns one should employ when "filling in" those organizational patterns. For example, Briana struggled to remember the names of common rocks and had to ponder carefully how textural labels were related to cooling history. She lacked the ability to put *meat* (semantic patterns) on the *bones* (organizational patterns) of her science discourse. In this regard, she was moderately successful in learning to talk geology.

Like Briana, Leo developed a sense of the organizational patterns needed to formulate a rock story. However, his understanding of these patterns was less well developed. Leo understood that all objects have a story but believed these stories could be represented in overly simple form. Leo's attempt to tell the story of his own body points to his naive understanding of organizational pattern: "My body came from my mom!" A complex idea such as human development was reduced to an overly simple statement. In an interview, Leo commented that, indeed, everything had a story. When asked to elaborate, he responded, "That book, it came from a factory. That glue, it came from a store. My shirt, it came from the store, too." Leo knew that considering origins of objects was a good beginning in the construction of a story but failed to move beyond this by perhaps asking, I wonder if this shirt can be found in stores in other countries? What
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<th>Posttest %</th>
<th>Gain %</th>
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<th>Semantic Patterns</th>
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<td>Brieana</td>
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<tr>
<td>Leo</td>
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<td>61</td>
<td>49</td>
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<td>Low</td>
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</tr>
<tr>
<td>James</td>
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does that tell me about its story? Further, Leo had difficulty understanding the more rich semantic patterns required to tell elaborate and scientifically accurate rock stories.

James, in contrast, easily developed the language and organizational patterns of the unit, telling rock stories quickly and fluently during his performance test. He was able to apply the basic linguistic heuristics and semantic patterns involving cooling speed and cooling environment (intrusive = slow cooling = big crystals; extrusive = rapid cooling = small crystals) and to employ them in the telling of rock stories. James could quickly and effectively string many science words together in ways that were scientifically accurate and warranted. In terms of learning the science discourse, James was successful.

Motivation to learn, in a discourse-based perspective, is most clearly found in the desire to enter particular discourse communities. Students desire this connection to others because it scaffolds their own efficacy and identity beliefs about themselves as science learners. It is here, at participation and motivation, where the three students’ discourse-based understandings most radically diverged.

Briana illustrates one view of emerging identity. As she gained proficiency in the ability to talk science, she developed a more coherent and clear image of herself doing the work of a geologist. Her geologist “future self” (Marcus & Nurius, 1986) became more clearly envisioned. Recall her elaborate account of herself as a geologist with a “cool safari outfit and hat . . . picking up rocks . . . and teaching other people about rocks.” Briana could literally see herself as a geologist to the point that she considered a career in the field.

Leo developed a sense of identity differently from Briana. Rather than imagining a possible future geologist self, Leo’s sense of identity was more local and more related to his efficacy beliefs as a science learner. Before this unit, Leo had enjoyed little success in his attempts to learn science. In this unit, however, he enjoyed success (for reasons illuminated by the view from aesthetic understanding) and began to see himself as a student who could engage intellectually with science ideas and with a teacher who valued his ideas and interests. Leo’s emerging identity did not have a career-centered focus (yet) but could be considered a possible “future science-learner self.” Most telling were Leo’s descriptions of his actions outside class searching for rocks, replicating class experiments, and checking out books from the library to further engage his science-learner self.

James, unfortunately, failed to develop further identity beliefs about himself as either a learner or a future geologist. He did not express any interest in imagining himself as a geologist and did not see himself any differently as a science learner, even after becoming proficient at talking about rocks. He expressed no interest in discussing geology ideas with others and found his ability to talk about rocks only peripherally related to his own interests. “I suppose I might need to know about rocks when I’m searching for ruins as an underwater archeologist.” His already well-defined future-underwater-archeologist-self and his already well-established success as a science learner did not leave James yearning for affiliation with this geology-related community. Perhaps, though, a different unit on oceanography (or another area of science) may have enticed James into considering alternative identities. As related to identity, James was only marginally successful in his discourse-based understanding.

A Deweyan Critique of Conceptual and Discourse-Based Perspectives

**Being.** Teaching for deep conceptual understanding is a challenging endeavor and is wisely given much attention in educational research and literature on pedagogy, reform, and assessment. What teacher would deny that teaching for understanding is outside the realm of his/her efforts?
Certainly we do not. However, too often teaching for understanding connotes a particular kind of understanding that most typically aligns itself with conceptual understanding as we have articulated it previously. Understanding of this type can be viewed as a “getting it” perspective on cognition. Students who acquire a conceptual understanding can represent what they know in clear, logical ways, can use that knowledge in multiple settings, and can (ideally) draw on that knowledge to assist them in the development of new understandings. “Getting it” goals are noble but often fail to satisfy urges to connect with beauty and to be inspired.

Our most significant concern in teaching for conceptual understanding is precisely this “getting it” metaphor. “I got it” suggests an end state, a point reached, a point that becomes static, lacks curiosity, inspiration, and anticipation. Students should understand important concepts, see connections across disciplines and relationships among parts and pieces, build mental models, become proficient in application and analysis. They should also develop fascination, passionate wonder, drives to think and act differently, to recognize beauty, awe, even feel fear and sense the sublime. Conceptual understanding fails to attend to the very dispositions that make people human, the dispositions students should be taught to cultivate and nourish. Shouldn’t teachers expect students to be moved to action, to live their lives differently after studying the effects of pollution and recycling? Teaching for conceptual understanding and the accompanying analytic lens tend to restrict educational outcomes to what happens inside the classroom, inside the head, and on the test. Similarly, teaching for discourse-based understanding desires students to use the language of science appropriately to investigate, communicate, and inquire about the world. Again, these are noble goals, ones with which we do not disagree. However, learning to talk and participate within a community is not learning to act, live, and be differently in the world. We believe a significant advantage of teaching for aesthetic understanding is that it expands the effect of school and learning to include contexts outside the classroom and school. Allowing aesthetics to focus learning, in science, for example, wedges the outcomes of that learning into the everyday lives of students. Recall Briana’s example in which throwing rocks into the lake became something of a value dilemma because she did not want to “throw away all those stories.”

Most teachers, or perhaps we should argue, more teachers, want to have an effect on student cognitions, actions, values, beliefs, and attitudes. Teaching for aesthetic understanding provides teachers with strategies for gaining more direct access to these student dispositions, provides compelling evidence for students to change, and offers an analytic lens with which to judge success or failure partly on the degree to which these student dispositions are altered. Teaching for aesthetic understanding does not neglect helping students to “get it” or to “talk it” but simply puts more emphasis on helping students “live it.” Aesthetic understanding is a perspective bold enough to weigh its success on the degree to which students think, act, and live differently as a result of learning. The notion of being, undergoing a transformation of self, is central to aesthetic understanding.

Coherence. Teaching for aesthetic understanding takes transformed person and world, or being, as a central desired outcome and organizes curriculum around Deweyan ideas to do so. Ideas may or may not have the kind of effect on learning and perception that students typically have in their classrooms. For example, imagine focusing a biology unit on the idea that animals are like works of art, uniquely adapted for and attuned to their environment in ways that are artistic and make them beautiful to observe and study. Imagine teaching students to see animals through the eyes of an artist, perhaps through the eyes of a nat-
uralist, to appreciate their qualities as well as the science behind their adaptations and survival strategies. Certainly this is a subtle refocusing of curriculum and attention to pedagogical nuance, but the results would be, in fact were, quite powerful (see Pugh, 1999). Students in such a class could just as easily learn concepts and discourses as well as gain a sense for new ways of thinking and acting in the world as they sought out and investigated new ways of viewing animal life. Aesthetic understanding, in allowing Deweyan, metaphoric ideas to guide curriculum, blurs the line between cognition/perception/emotion, and content/world/other in productive ways.

Anticipation. Central to issues of motivation and engagement in the perspective of aesthetic understanding is the notion of anticipation. The first author recalls a comment made by another student learning geology in this same classroom: “I have all these rocks at home, and I can’t wait to get home and try to tell their stories. I want to look at them now!” Although this student was not one of the case study students, her comment exemplified the power of Deweyan ideas and the tension and anticipation they create as students seek to test or verify the power of the idea in contexts defined on their own terms—outside of school, on personal time, without the prodding of the teacher or an assignment. The perspectives of conceptual and discourse-based understanding do not illuminate any sense of urgency or immediacy in engagement or interaction with subject matter. In fact, motivation to learn is one of the most significant impediments to deep engagement in schools (Brophy, 1998). Pedagogy and learning theory that are centered on ideas and aesthetic understanding sidestep many engagement issues simply by portraying learning in unique and compelling ways. Combined with the forward-looking, anticipatory quality of Deweyan ideas, student engagement is less an issue in a classroom focused on aesthetic understanding. Leo, for example, a student familiar to the principal’s office for off-task behavior, frequently had to be chased out of the classroom at the end of our science lessons. His newfound ability to say meaningful things (scientifically accurate) about ordinary objects (rocks) created a sense of urgency and anticipation to engage with these ideas and activities as often and as deeply as he could. In fact, he enjoyed finding rocks and bringing them to show to the class so much that his desire to find increasingly interesting specimens drove him to steal a decorative rock from his neighbor’s yard. Imagine learning so powerful that it compels one to act outside a moral code. Anticipation and tension are central elements of the compelling and dramatic nature of teaching and learning for aesthetic understanding.

The final section of our analysis examines the cases through the lens of aesthetic understanding and focuses on how this perspective speaks to the issues we critique above.

Aesthetic Understanding

As with the other perspectives, Brieana again seems to have experienced a high degree of success. Leo and James, however, responded quite differently. Aesthetic understanding allowed the before-hidden success of Leo to shine while simultaneously illuminating the areas in which James was unsuccessful. Perhaps one role of aesthetic understanding is to make judgments of success and failure of learning more complex. Human understanding is a richly textured phenomenon, and to reduce it and represent it too narrowly, as we believe other perspectives on understanding do, is to ignore the richness of human experience.

We begin with Brieana. Her perceptions of the world, and herself as a person interacting in this changed world, grew with her understanding of the subject matter. Recall her words, “I think about rocks differently than I did before we studied them. I try to tell their stories. Most people don’t think about their stories.” Through a powerful, Deweyan idea, Brieana’s ordinary experi-
ences of looking at the rocks in her rock collection and skipping rocks on the lake near her home were transformed into aesthetic experiences as she became intensely engaged in imagining and constructing rock stories. This combination of changed perception of world and person is powerful for her, as is seen by her comment toward the end of her case study: “I was thinking about the number 2. What’s the story behind it? Who named it that and why is it so important?” Brieana’s newfound narrative worldview, originating in rocks and rock stories, grew outside of her classroom experiences to draw her into more deeply felt and experienced interaction with the world. Brieana’s eyes and mind had been opened to a new and different way of being. A powerful education should promote in students these kinds of feelings, attitudes, dispositions, and readiness to interact, explore, and appreciate the world.

Perhaps the only element of Brieana’s unfolding aesthetic understanding that lagged was the one that corresponds most closely to conceptual understanding—the degree to which ideas bring coherence or unity to one’s understanding of the world. Although Brieana clearly learned a great deal, and this learning brought much into focus for her, she did not describe her understanding in ways that indicated much unification of ideas and concepts. Brieana simply did not describe her new geology knowledge as providing any unique sense of coherence in her world.

Unlike Brieana, Leo and James appear very differently when viewed from the perspective of aesthetic understanding. From the other two perspectives, Leo appeared marginally successful, barely avoiding failure, whereas James excelled. Aesthetic understanding closes this gap.

Leo was gifted with a vivid imagination. Imagination and the courage to employ it are not always valued skills or activities in school. Learning for aesthetic understanding, however, requires one to employ creativity, imagination, and invention in meaningful ways. The power and potential of Deweyan ideas can be verified in the world or inside one’s mind (a successful teacher provides opportunities to do both), and in these situations Leo came alive. He could vividly describe what it felt like as a molecule within a pool of molten lava, as ejecta raining down from an erupting volcano, and as a rock being worn and eroded by running water and sediments on the bottom of a river. Because the learning goals had shifted in his science class, Leo was suddenly encouraged to act on his imagination and become a valuable member of the community as he used richly descriptive language to describe the lives of rocks.

As Dewey would expect, Leo’s unfolding experiences with science ideas led to more and deeper contact with ideas and the world. Rather than resist participation in class activities as he had before, Leo eagerly participated in class experiments, replicated them at home, told his mother and little brother about his experiences in school, and even checked out his first books from the school library. Leo’s fascination with rock stories affected his life outside school. Reading unassigned books, talking about schoolwork outside school hours, and searching out opportunities and experiences with science ideas on his own time, Leo had become a model student.

As did Brieana, Leo moved the least toward an articulation of the coherence his learning provided to his world. Certainly Leo learned a great deal and understood many parts of the world better, but, again, he did not experience the quality of unification that other students, such as James, experienced. However, in defense of Leo, he was a poor reader and writer with a poor academic record. We believe that, had he been exposed to teaching for aesthetic understanding for a longer time, Leo would have continued to find success in science class, and this success would eventually have led to successes in other subjects. He might have begun to perceive himself and
be perceived by his peers as academically successful.

James, like Brieana, appeared successful by most standard measures. However, unlike Brieana, James failed to have aesthetic and transformative experiences. James stated plainly, “Yes, I think rocks are more interesting now than they were before, but I don’t go around thinking about the stories of rocks or anything else.” James felt no sense of anticipation, drama, or tension as he learned how to tell rock stories and verified the power of the idea for himself. Although James described a situation in which he told his parents rock stories at the beach, he followed the story with this explanation, “I can tell my parents rock stories at the beach, if they want, but mostly I just skip them.” Telling rock stories failed to create a sense of drama and urgency in James. He could tell rock stories if his parents asked him to do so but did not feel driven, or even slightly compelled, to communicate his understanding to others. Many reasons could explain why this unit failed to “grab” James, but we argue his response can best be attributed to his rigid view of “doing” school. James had remarkably focused goals for a 10-year-old. He knew what to do to get good grades, had a career goal in mind, and behaved in ways that garnered him the support and admiration of his teachers. As indicated previously, the regular classroom teacher identified James as one of the smartest students in class and treated him accordingly. However, when asked to shift his attention away from concepts and definitions to beauty and artistry, James faltered. These qualities of learning and experiencing the world seemed too alien to James, and he could not relinquish standard goals and strategies as easily as some of his classmates—perhaps because he had more to lose. Table 2 represents understanding in each of the three perspectives.

**Discussion and Conclusions**

Critiques of earlier drafts of this article suggested that perhaps the power of the pedagogy was not in the framework of learning for aesthetic understanding but in equally powerful narrative ways of knowing. We do not discount the role of narrative; in fact, we respect much earlier work in this area (Bruner, 1990, 1996; Egan, 1989, 1997). We contend, however, that narrative ways of knowing are effective for the same reasons that learning for aesthetic understanding is effective. A true narrative perspective on the world and its objects helps students to see things differently, begs them to ask questions and engage in inquiry—the same qualities of aesthetic understanding. To further push this line of criticism, has Egan (1997) already described learning for aesthetic understanding as a combination of his mythic and romantic understanding? Perhaps in part. Just as Egan describes powerful learning through mythic and romantic ways of experiencing and knowing, we describe powerful learning from aesthetics and enhanced perception. Egan argues for the role of imagination, fantasy, metaphor, and humanized knowledge—just as we have done. The central similarity between the two arguments is that powerful ideas lie at the center of learning experiences. A central dissimilarity is that Egan’s theories do not put subject-matter ideas at the center of these experiences—allowing instead for these ideas to be conveyed by other narrative experiences. Teaching for aesthetic understanding, as exemplified in this case by learning to tell rock stories, works because subject-matter ideas are at the center of the pedagogy. A central goal in the field of geology is to recreate or interpret the geologic history of regions, formations, and strata. Students were engaged in this activity from the outset of the unit.

Employing multiple perspectives in analysis forces one to question the goals of education and schools. Is educators’ task to help children gain conceptual understandings or ways of talking and participating in the social context? Is either goal enough—or both together? What good is this learning if it does not fundamentally change the way…

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students see, live, feel, and act in the world? James illustrates this tension in goals perfectly. He succeeded in many ways but failed to find value in subject-matter ideas. He felt no significant sense of anticipation or inspiration and exited instruction with a mostly untouched sense of "being." Certainly James experienced a degree of conceptual unity because he gained a great deal of conceptual understanding. However, this knowledge failed to leave him with a heightened sense of awareness, curiosity, or beauty of the world. His understanding failed to "grow legs" in the sense that it did not carry him out into the world to new and enriched experiences. For this reason, his understanding had no sense of aesthetic value and represented something opposite to aesthetic understanding.

We are not suggesting that educators abandon the goal of teaching for conceptual understanding. In fact, we realize the importance of and challenge often faced in meeting this goal. Similarly, we applaud discourse-based pedagogy in its success at inviting more students into scientific engagement. However, we also believe that perhaps these goals should not be at the center of instructional efforts, which should focus instead on students having educative, aesthetic, Deweyan experiences with important science ideas. In defense, we believe conceptual understanding that results from aesthetic experience is more deeply felt because it is centered on powerful ideas rather than concepts. As students are transformed by their experiences and heightened sense of being, their perceptions of themselves and the world are altered. For this reason, we believe conceptual learning that occurs as a result of aesthetic experience is perhaps more enduring, more deeply felt, and more generative for students as they go about their daily lives. Initial research confirms this hypothesis (Girod, 2001). As for engagement and participation in a discourse-focused classroom, we believe these too will be subsumed by goals of teaching for aesthetic understanding. Motivation through anticipation, verification of possibilities, and subsequent consummation is energizing. Students who are learning for aesthetic understanding are drawn into engagement with ideas, their imaginations, and the world as they seek new and richer experiences.

Getting—dare we say, coercing—students to engage with science and participate in inquiry will become less of a challenge as students realize the liberating potential of science as portrayed and learned for aesthetic understanding. Teaching for aesthetic understanding is a more holistic, experiential, and artful perspective on learning and may invite a broader range of students to engage with science ideas. If educators wish "science for all" (American Association for the Advancement of Science, 1989), then they must begin to employ pedagogy and analytic lenses that help them to foster and judge more holistic teaching and learning goals.

References


