Science, Art and Experience:

Constructing a Science Pedagogy from Dewey's Aesthetics

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Abstract

Drawing on the work of Dewey, we present a view of science education from the perspective of art and aesthetics. This perspective places transformative, aesthetic experience at the forefront of educational objectives. Such experience involves the application of learning in everyday contexts, expansion of perception, and development of an increased interest in science ideas and aspects of the world illuminated by those ideas. After describing this educational objective, we present a pedagogical model focused on the fostering of transformative, aesthetic experience. This model involves two general categories of instructional methods: (1) methods of crafting ideas out of concepts, and (2) methods of modeling and scaffolding transformative, aesthetic experience. We discuss how the methods comprising this pedagogical model relate to established science education methods.

Introduction

> *[Art] quickens us from the slackness of routine and enables us to forget ourselves by finding ourselves in the delight of experiencing the world about us in its varied qualities and forms.*
>
> Dewey, *Art as Experience*, p. 110

> *I have a friend who's an artist, and he sometimes takes a view which I don't agree with. He'll hold up a flower and say, "Look how beautiful it is," and I'll agree. But then he'll say, "I, as an artist, can see how beautiful a flower is. But you, as a scientist, take it all apart and it becomes dull." I think he's kind of nutty . . . There are all kinds of interesting questions that come from a knowledge of science, which only adds to the excitement and mystery of a flower. It only adds.*
>
> Richard Feynman, *What do you care what other people think?* p. 11

With today's emphasis on standards, proficiency testing, and international comparisons, it is easy to forget the artful side of science. That is, it is easy to forget – or fail to even realize – that science has a potential to enrich everyday life, vitalize experience, and provide us with aesthetic satisfaction. For instance, as science educators, we often obsess over misconceptions but fail to ask whether students ever apply their "correct" conceptions outside of school and use them to have aesthetic experiences in the world. We are more likely to ask questions like, "Do students understand the concepts correctly?" than "Do the concepts make any difference in the students everyday, out-of-school lives?"

Nevertheless, scientists such as Feynman and some science educators have paid attention to the artful side of science. To name just a few: Root-Bernstein (1997) has argued that science and art share a common underlying aesthetic motive and aesthetic theory; Holton (1978) argues for the role of imagination and artistic creativity in science; Chandrasekhar (1987), suggests scientists find motivation and desire to participate in science through aesthetics; McAllister (1996) appeals to aesthetics as a critical factor in a highly rational account of scientific progress and revolution; Flannery (1991) identifies aesthetic aspects in the process of learning and doing

science; while Fischer (1999) seeks to blur the boundaries between science and art almost completely.

Despite this work, science education is still largely focused around standards, conceptual change, and inquiry. These are some of the dominant paradigms that shape current science pedagogy. What if art and aesthetics were to join the ranks of these dominant paradigms? What might science pedagogy look like if art and aesthetics were a driving force? In this paper, we address this question by proposing a science pedagogy derived from Dewey's writings on art, aesthetics, and experience. In the spirit of educational philosophy, our intent is to spark the imagination, to provide an alternative vision of what could be.

Dewey's Aesthetics

Before moving into a description of the proposed pedagogy, we take the time to explain why we have turned to the work of Dewey and we attempt to explain some of his key ideas regarding aesthetics in a manner accessible to the non-Deweyan scholar.

In the past, Dewey's work has been associated with notions of *learning by doing* or *learning through experience*. Indeed, there is a vast literature in science education that examines the ways in which enriched forms of experience contribute to the learning of concepts, and this literature fits nicely with many of Dewey's ideas. However, there is an equally important, but less celebrated, aspect of Dewey's work associated with the complement to learning through experience: *experience through learning*. This latter notion is at the heart of his writings on art and aesthetics. When combined with his other work, these writings provide insight into how *learning concepts can foster enriched experience* – not just in the classroom, but in everyday life. Specifically, Dewey's aesthetics provides a conceptualization of what it means to engage in

a particularly meaningful and transformative experience, and his writings on ideas provide insight into the role that the learning of concepts may play in such experience.

Before moving on, we offer a final note of clarification. Dewey's writings were extensive and anytime we evoke Dewey's name, we open ourselves to the criticism that we are not taking into account this or that aspect of his work. Hence, we want to be upfront in stating that we are focusing just on Dewey's aesthetics and some of his work that parallels the ideas in his aesthetics. Dewey himself never fully articulated the implications of his aesthetics for education. In this paper, we develop implications from his aesthetics, but we acknowledge that other implications are possible. In the spirit of pragmatism, we suggest that the worth of these implications be judged by their consequences. That is, by their capacity to spark the imagination, provide new insights, and inspire fruitful actions.

Transformative, Aesthetic Experience

An argument can be made that Dewey turned to art and aesthetics, not so much to develop a theory of art, but rather to extend his theory of experience. Indeed, *Art as Experience*, Dewey's preeminent work on aesthetics, may just as fittingly been titled *Experience as Art*. In the arts, Dewey found a fertile context for conceptualizing an "enriching" or "optimal" experience. Dewey (1934/1958) believed that successful participation in the arts epitomized a very special type of experience – what he called *an* experience. Like a drama, a*n* experience is an event that has its own completeness, is easily remembered, and is readily differentiated from other events and experiences (Pugh, 2004; Wong, Pugh and the Deweyan Ideas Group at Michigan State University, 2001). Moreover, the experience involves a build up and resolution of anticipation. Indeed, it is this build up and resolution of anticipation that gives the experience its completeness and uniqueness. However, what makes *an* experience truly important is that it

brings about a transformation of one's relationship with the world. Deweyan scholar Philip Jackson (1998) explains,

> Our interactions with art objects epitomize what it means to undergo *an* experience, a term with a very special meaning for Dewey. The arts do more than provide us with fleeting moments of elation and delight. They expand our horizons. They contribute meaning and value to future experience. They modify our ways of perceiving the world, thus leaving us and the world itself irrevocably changed. (p. 33)

In *an* experience, a person's relationship with the world is transformed as the person comes to see some aspect of the world (which may include other people or oneself) in a new way, to find new meaning in this aspect of the world, and to value this new way of seeing. Through *an* experience, a person literally comes to be in the world differently (Wong et al., 2001).

At the time Dewey was writing *Art as Experience*, he also revised one of his classic educational texts, *How We Think*. It is interesting to note that in the revision of *How We Think*, Dewey (1933) devotes considerably more attention to the construct of an *idea* (Prawat, 2000). This is significant, because his conception of what it means to engage in an idea resembles his conception of what it means to engage in *an* experience. For Dewey (1933), ideas are possibilities. As such, they foreshadow future happenings, awaken anticipation, and initiate action. Powerful ideas lead to new ways of thinking about the world and new ways of acting on it as we put the ideas into action. According to Dewey (1929/1988), worthwhile ideas "pass into actions which rearrange and reconstruct in some way, be it little or large, the world in which we live" (p. 111).

What we may conclude from this is that ideas have the same potential as art to transform our relationship with the world by opening up new experiences, and allowing us to see and act on

the world in new ways. For Richard Feynman (1989), science ideas allowed him perceive such things as flowers in meaningful, new ways. Likewise, Richard Dawkins (1998) claimed that science books led him to perceive and experience the world as "a much fuller, much more wonderful, much more awesome place than I ever realized it was" (p. 37). Moreover, engagement in an idea involves a build up and consummation of anticipation (Pugh, 2004). The idea creates anticipation about how we can be in the world differently, and this anticipation reaches a consummation as we act on the idea and undergo the consequences. The experience of engaging with an idea has its own uniqueness and completeness that makes it stand out from ordinary experience. In other words, when we engage with powerful ideas we experience many of the same qualities that define *an* experience.

Based on the work of Dewey described above, Pugh (2002) has developed the construct of *transformative experience* and used it as an analytic tool for studying engagement in science students. He offers the following definition:

> a transformative experience may be defined by three principle qualities: 1) active use of the concept, 2) an expansion of perception, and 3) an expansion of value. Active use means the individual seeks out or takes advantage of opportunities to use the concept as a potential lens for more fully perceiving the world [particularly in everyday, out-of-school context where the student is not required to apply the concept]. . . . Basically, individuals undergo transformative experiences when they actively use a concept, find that it allows them to see aspects of the world in a new way, and personally value this way of seeing. (p. 1104)

Similarly, the Girod has developed the construct of *aesthetic understanding* from Dewey's work and has used it to investigate science learning. Aesthetic understanding is a rich

network of conceptual knowledge combined with a deep appreciation for the beauty and power of ideas that literally transform one's experiences and perceptions of the world (Girod, Rau & Schepige, 2003; Girod & Wong, 2002). Aesthetic understanding pushes students to see, think, and act differently as a result of new learning. The critical elements in the construct are: 1) changed perception – of both self and world; 2) renewed interest and excitement, and; 3) added clarity in thought or comprehension.

While we have used some different language in trying to conceptualize what it means for students to experience aesthetic outcomes (of the type Dewey describes) in the realm of science education, we are generally interested in the same goal. We want students to *be* differently in the world because of powerful science ideas. As part of this goal, we emphasize the importance of application of learning outside of school, changed perception, and increased interest in science ideas and aspects of the world illuminated by those ideas. For the purposes of this paper, we will refer to this outcome as *transformative, aesthetic experience*. In other papers, we provide case-studies that illustrate what it means to engage in such experience and how it differs from other types of engagement (Pugh, 2004, Girod et al., 2003, Girod & Wong, 2002). In this paper, we address the pedagogical question of how to teach for transformative, aesthetic experience. While initial studies (Pugh, 2002; Girod et al., 2003) have confirmed the effectiveness of aspects of the pedagogical model described in this paper, what we present is largely a theoretical model (or set of ideas) derived from Dewey's extensive philosophy of experience and aesthetics. That is, the model represents a view of what science education might look like if approached from the perspective of art and aesthetics.

Creating a Transformative, Aesthetic Science Education

The pedagogical ideas presented in this paper can be placed into two general categories:

those that involve crafting ideas out of concepts and those that involve the modeling and scaffolding of transformative, aesthetic experience. There is some necessary overlap of these categories, but enough distinctiveness to merit the separation. A summary of the methods is depicted in Table 1. While these methods resemble some familiar practices in science education, there are important differences in the details and orientation of the methods – mainly, the difference lies in these methods being focused on fostering transformative, aesthetic experiences, instead of being focused on such things as building conceptual models, confronting misconceptions, or developing inquiry skills. We will highlight some of these similarities and differences as we discuss each method. Although we believe this pedagogy is unique, we do not believe that it is incompatible with other approaches or that it could not be integrated with pedagogical models focused on such things as conceptual change or inquiry.

Crafting Ideas Out of Concepts

A misgiving Dewey (1934/1958) expressed is that "when an art product once attains classic status, it somehow becomes isolated from the human conditions under which it was brought into being and from the human consequences it engenders in actual life experience" which in turn renders the general significance of the product "almost opaque" (p. 3). As a result, the product fails to expand perception and vitalize experience. The same could be said of the "classics" that comprise our curriculums. When intellectual products attain classic status, they become isolated from the conditions in which they had an original significance and from their potential consequences for everyday experience. As a result, their importance is reflexively accepted but not fully appreciated. Another way of putting it is that we often teach concepts instead of engaging our students in ideas. Dewey (1933) explains that concepts are established meanings ("classics"); whereas, ideas are possibilities that must be acted upon and tried out.

Concepts are forms of knowledge. Ideas are ways of being in the world. They are inseparable from human experience (Wong et al., 2001). Hence, we see one of the primary duties of the teacher to be the crafting of concepts into living ideas so that the content may become a catalyst for transformative, aesthetic experience. Of course the teacher cannot do this alone. The experience requires a transaction involving the teacher, content, environment and student (Dewey, 1938). Nevertheless, the teacher plays a critical role in this transaction. Below we describe promising methods for fostering engagement with *ideas*.

Restore concepts to the experience in which they had their origin and significance. In one of his early and oft cited writings on education, Dewey (1990/1902) admonishes teachers to "psychologize" the subject matter. In other words, it needs to be "turned over, translated into the immediate and individual experiencing within which it has its origin and significance" (p. 200). One interpretation of this statement is that concepts need to be restored to the experiences in which they were first developed and debated *as ideas*. Thus it is important to remember that even the most mundane, taken-for-granted concepts were once powerful – perhaps even disturbing – ideas. Take the Copernican view of the Solar System as an example. Today the concept that the Earth revolves around the Sun is so ordinary that we don't even think about it twice. But it was once an exciting and disturbing possibility that inspired new actions and transformed the way people thought about the earth and humanity in some surprising ways. Hence, one way of crafting ideas out of concepts is to help the students appreciate and experience the birth of a concept as an idea. Doing so may involve such things as helping students understand the historical context in which the concept first originated and helping them recognize the important transformations that resulted from it. This is sometimes easier said than done. We don't often spend our time contemplating the original significance of the content we teach (after all, most of

the concepts are "classics" whose significance is not questioned), and hence don't have ready answers (neither do most textbooks or other curriculum material). Discovering the original significance may require some research, conversations with knowledgeable others, and sustained reflection on what *you* sense as the real significance.

As an example, consider a teacher preparing to teach a unit on Newton's Laws – a true curriculum "classic" whose status and importance is rarely called into question. But why are Newton's Laws important? What impact did they have on science and the world at large? To help the students appreciate that Newton's Laws were not always *laws* and to help the students appreciate their origin as powerful ideas, the teacher may choose to dramatize them with a statement like the following:

> Isaac Newton came up with a few simple ideas about the movement of objects. You might think such a thing wouldn't make much of a difference. We all come up with ideas all the time. But Newton's ideas were different. His ideas came with a magnificent, but terrifying power – the power to explain, predict, and control the world to a frightening degree. Since that day, the world has never been the same.

The teacher could then engage the students in a discussion of how Newton's ideas changed the way people interpreted and acted on the world, contributed to the rise of the scientific worldview with all its consequences, and impacted fundamental religious and philosophical beliefs at the time (not only did Newton's Laws influence science, but they had an impact on beliefs about such things as the nature of God and human free will). Alternatively, the teacher may choose to refrain from presenting his/her view of the original significance of Newton's Laws and instead provide resources for the students themselves to research the origin of Newton's Law's and answer the question of why they are important.

Activities that help students appreciate the original significance of the content are important because they help remove the barriers to reflection caused by the "classic" status of the concept. They help students see the concept as the compelling idea it originally was.

This method is a version of the familiar method of putting content in a historical context. Pedagogies with different theoretical bases use this familiar method in different ways. For instance, a cognitive pedagogy may use this method to integrate science with history in the hopes of creating a richer, more elaborate knowledge structure. Likewise, a nature of science pedagogy may use this method to teach students about how science works and how knowledge is constructed. Each pedagogy emphasizes different aspects of the historical context depending on the pedagogy's goal. From a Deweyan perspective, the goal is to help students appreciate concepts *as ideas*. Hence it would be important for the teacher to emphasize the original conditional nature of the concept, the way it generated anticipation and action, and the way it transformed peoples' perception and experience.

Foster anticipation and a vital, personal experiencing. Another aspect of *psychologizing* the subject matter is to connect it to students' experience in a special way. Nearly all instructional approaches emphasize the importance of connecting subject matter to student experience, but Dewey had something more in mind than what we typically do. He felt that teachers need to connect subject matter with experience in such a way that it induces "a vital and personal experiencing" (1902/1990). That is, students need to take the subject matter into their everyday lives and fully experience the consequences of "living" the subject matter ideas.

In order to induce a vital personal experiencing of the subject matter, teachers need to do more than simply show students how the subject matter relates to their experience. This is a good start, but teachers also need to create anticipation. Anticipation is key to transformative, aesthetic

experience, because it is an instigator of action (Wong et al., 2001). Just as suspense moves a drama forward, anticipation moves students to act on and experience ideas.

How can anticipation with respect to experiencing ideas be fostered? One approach is to carefully craft the subject matter in a similar way that an artist does. A drama writer, for example, carefully chooses what words, images, descriptions and action sequences will go into a manuscript (many are rejected). These vital elements are then crafted together in a particular order and form so that they build on themselves and create a growing suspense and plot line. Teachers can do the same thing with content. They can carefully select the elements of the content that are most vital and craft these together with an eye towards the development of anticipation and personal experiencing.

An intriguing example of how content can be crafted in an artistic way with an eye towards the development of anticipation and personal experiencing is presented in the movie *Dead Poets Society* (1989). In this movie, Robin Williams as the character of Mr. Keating (an English professor at an all-boys prep school) introduces his students to the world of poetry and literature through this carefully crafted monologue:

> In my class . . . you will learn to savor words and language. No matter what anyone tells you, words and ideas can change the world. . . . I have a secret for you. Huddle up. [the class gathers around Mr. Keating and he bends down] We don't read and write poetry because it's cute. We read and write poetry because we are members of the human race and the human race is filled with passion. . . . Medicine, law, business, engineering; these are noble pursuits, and necessary to sustain life. But poetry, beauty, romance, love – these are what we stay alive for. To quote from Whitman, "Oh me, oh life, of the questions of these recurring. Of the endless trains of the faithless. Of cities filled with the foolish.

> What good amid these, oh me, oh life?" Answer: that you are here. That life exists, and identity. That the powerful play goes on and you may contribute a verse. That the powerful play goes on and you may contribute a verse. [pause] What will your verse be?

Through these carefully selected statements, Mr. Keating conveys the importance and meaning of poetry and language. He creates anticipation regarding such things as how words can change the world, what it means to be filled with passion and express this passion through poetry, and how one might personally contribute to the world. Such statements and anticipation can move the individual to engage in a vital personal experiencing (or "passionate experimentation" to take a phrase from one of Mr. Keating's students) with poetry and language.

We, the authors, lack the mastery of language possessed by the script writers for the movie *Dead Poets Society*. Nevertheless, we have made our own fledgling attempts at crafting curriculum in compelling ways such that it fosters anticipation and evokes passionate experimentation with the subject matter.

For example, Pugh (2002) was presented with the task of teaching adaptation and evolution in a 10th grade zoology class. He determined that a vitalizing element in these concepts was related to a fascination with the relationship between form, function, and environment. Hence, after viewing and discussing some home video clips of remarkable animals (e.g., a grizzly bear and moose) and having the students write and talk about their favorite animals, he shared the following statement:

> What we want to do this week is learn more about how every animal is truly an amazing design. Because every animal . . . is designed to survive and thrive in a particular environment. And when you learn how to see animals in terms of how they're adapted to their environment, every animal becomes an amazing [creature].

The term “design” was a bad choice as it implies an intentional or creationist view of evolution, but the intent of the statement was to capture the drama of perceiving animals in terms of the relationship between form, function, and environment. In the future, it would be advantageous to seek language that conveys the correct scientific concept, but avoids the mundane presentation of a neutral scientific definition.

The rest of the unit was focused around the activity of learning to see and appreciate animals for the amazing creatures that they are. The intent here was to tap into existing interests and create anticipation about how animals could be seen in an exciting, new way. If fostered, this anticipation would lead the students to have their own vital and personal experiencing of the subject matter by moving them to see animals differently in their everyday lives (which most of them did).

This approach to instruction and curriculum design can be contrasted with the approach of a typical standards-based curriculum. In a standards-based curriculum, the standards become ends unto themselves and coverage becomes the driving force. From the Deweyan perspective, the subject matter becomes a means to vital, personal experience and the artistic crafting of the subject matter is the driving force. The focus is on how the subject matter can be crafted so that it generates anticipation and personal experiencing. This leads to relatively less emphasis on coverage of content and more emphasis on using content to enrich experience.

It is also important to note that a focus on anticipation is similar to but distinct from a focus on interest (which is common to many current science pedagogies). This difference may again be highlighted by looking at means and ends. Pedagogies that contain a focus on interest typically do so for one of two reasons. Either interest is seen as a valuable end unto itself or else it is seen as a means to deeper learning. From a Deweyan perspective, anticipation – which may

be conceived of as an action-oriented form of interest – is seen as a means to the personal experiencing of the content. Hence, in a Deweyan pedagogy, emphasis would be placed on not just getting students interested and developing deep understanding but getting students to engage in their own "passionate experimentation" of the content. This may lead to subtle differences in how teachers present ideas and structure activities. For example, a constructivist pedagogy in which students explore the concepts of adaptation and evolution through an investigation of endangered species is likely to generate interest in the concepts of adaptation and evolution. However, by itself, this pedagogy may be insufficient to develop the sort of anticipation that will lead students to engage in their own vital experiencing of the ideas outside of class. Specific attempts to generate anticipation about what it is like to see and experience the world through the lenses of adaptation and evolution may be necessary to achieve this latter purpose (note, this example is based on the results of a study by Pugh, 2002).

Use metaphors and "re-seeing" to expand perception. Expansion of perception is at the heart of Dewey's aesthetics. Dewey (1934/1958) wrote that ordinary living, routine, un-observed interaction with the world causes us to lose touch with the uniqueness and originality found in the world, "apathy and torpor conceal this expressiveness [of ordinary objects] by building a shell about them." Art, however, "throws off the covers that hide the expressiveness of experienced things." He continues, "it quickens us from the slackness of routine and enables us to forget ourselves by finding ourselves in the delight of experiencing the world about us in varied qualities and forms" (p. 109-110). Jackson (1998) further explains,

> The centrality of perception in Dewey's theorizing about the arts, and about experience in general, can hardly be overemphasized. Not only must we perceive art objects in order to appreciate their worth, but doing so is at least one means by which we come to better

perceive other objects and events, including ourselves and others. (p. 113)

In ordinary living, we tend to rely on recognition. That is, we immediately recognize objects as being of a particular type or class. Dewey (1934/1958) explained that "in recognition, we fall back, as upon a stereotype, upon some previously formed scheme" (p. 52 – 53). But art teaches us to *perceive* objects. It teaches us to go beyond mere recognition and look at objects (and not just art objects) from fresh, new perspectives. This quality is what makes the arts so important in Dewey's view.

As stated earlier, we argue that science content possesses a similar potential to expand perception. Indeed, one of the key qualities that separates a concept from an idea (in the Deweyan sense) is that an idea leads to an expansion of perception. One of the key challenges of a Deweyan science pedagogy is actualizing this expansion of perception. Here we present two promising methods for achieving this outcome: use of metaphor and the teaching of "re-seeing."

Cognitive scientists have long touted the power of metaphor to connect concepts to objects and events in the physical world (Johnson, 1990; Ortony, 1979). Scientists have similarly employed metaphor to aid creative thinking (Root-Bernstein & Root-Bernstein, 1999). Like ideas (in the Deweyan sense), metaphors are about possibilities – possible connections, representations, or explanations. Too often learning is portrayed as resolving gaps in our knowledge or solving problems that we may encounter. We argue, however, that using metaphors allows learning to be about what may be, to appreciate the affordances of new ways of thinking, seeing, and acting. Hence metaphors can engage students in the experience of an idea. Indeed, the Deweyan notion of *abduction* (which he borrowed from Peirce) places metaphor at the center of the learning process (see Prawat, 1999).

An example of how metaphor can lead students to engage with concepts as ideas and

experience an expansion of perception is provided in a study by Girod (2001). In this study, erosion was taught to 5th graders as a battle between the earth's resistive features and those forces that destroy it. This battle metaphor provided students with a lens that students could try out in their everyday lives. For instance, one student explained,

> I guess I knew about erosion before but I didn't really know it was all around us, happening all the time. I see it everywhere I go now. At recess all us girls we normally sing and dance around the school but yesterday we went around the school looking for erosion. (p. 139)

The use of metaphor in science pedagogy is not new. Science educators have advocated the use of metaphor or analogy for a variety or reasons ranging from their use in overcoming misconceptions (Stavy, 1991) to their use as an entry point through which students may engage in the practice of knowledge construction (Wong, 1993). Here we wish to emphasize the use of metaphor as a tool for the expansion of perception. That is, metaphors provide possible ways of seeing and experiencing the world. In a Deweyan pedagogy, teachers would not only present metaphors, but place emphasis on the wonder that comes from trying out such metaphors in one's everyday experience. For instance, in the study mentioned above (Girod, 2001), the teacher not only presented the battle metaphor, but animatedly told the students that they could see this battle going on everywhere and encouraged the student to go look for it. Without this extra emphasis on using the metaphor to expand perception, it is unlikely that the girls would have gone around the school at recess looking for erosion.

We see metaphor as a catalyst to expanded perception. However, we also believe that deep perception is a skill unto itself. Nobel-prize winning biologist Konrad Lorenz recognized the importance of this skill. He describes the intimate connection between deep perception and

excellence in science while simultaneously acknowledging that deep observation falls typically in the domain of art. “He who has once seen the intimate beauty of nature cannot tear himself away from it again. He must become either a poet or a naturalist and, if his eyes are good and his powers of observation sharp enough, he may well become both” (Lorenz, 1997, pg. 237). This level of perception – deep, sustained, and inquiring – must be taught. One way to do this is to teach students the art of “re-seeing.”

Re-seeing involves explicitly teaching students to look at ordinary objects from a new perspective. For example, in teaching science to 5th graders, Girod (2001) would identify common objects, such as the Moon, that could be seen differently if viewed through the lens of a particular science idea. Then, he would encourage the students to “re-see” these objects in their everyday lives. He would also give students the opportunity to share their experiences of re-seeing in class, and would take time to share his own attempts at seeing differently. Eventually, his students got caught up in this notion of re-seeing. For instance, one student exclaimed excitedly, “I did some re-seeing last night! I could actually see different shapes and things on the Moon and I could tell that it was just a shadow that made it look like a fingernail.” Re-seeing helped this student to take some basic science understanding and use it to expand his perception. When science learning moves into students’ everyday experience in this way, then the science concepts begin to function as ideas.

As another example, Pugh (2002) taught 10th grade biology students to use the concepts of adaptation and evolution to re-see animals. Once again, many students came to perceive animals in a new light. In response to a survey question asking students whether they had changed the way they see and think about animals, one student wrote,

> I now don't just look at [an] animal and say, 'That's cute.' I stop and think a little harder. . . I wonder if they are closely related to me as a human. I also think about their markings and how it helps them. . . [the concept of adaptation] made me look past the animal and made me try to understand more about it.

The above response is a good example of what Dewey means by expansion of perception and the role that science can play in expanding perception.

Re-seeing is closely associated with science pedagogies and standards that emphasize connecting science learning to experience. Indeed, it may be seen as a way to connect science learning to experience such that it emphasizes and supports perceptual transformation. This perceptual focus is also an element of some inquiry-oriented approaches to science education. Such approaches often explicitly teach disciplined perception. That is, they teach students how to notice detail, look for patterns, carefully represent nature in a concrete, factual account, and so on. However, there is a difference. While inquiry-oriented approaches emphasize disciplined, scientific perception, a Deweyan approach emphasizes aesthetic perception (i.e., finding new meaning in common or taken for granted objects and events). Nevertheless, these two forms of perception are not incompatible and both are important to science learning.

Modeling and Scaffolding of Transformative, Aesthetic Experience

Along with Mead, Dewey worked out a theory of the social origin of mind (Garrison, 1995). Today, this theory and the work of Vygotsky (1978; 1986) are foundational to the situative perspective that views learning as a process of enculturation (Brown, Collins & Duguid, 1989; Greeno, Collins & Resnick, 1996). This perspective places emphasis on participation in sociocultural activity. As individuals come to participate more centrally in sociocultural activity, they appropriate the knowledge, skills, and values inherent in the activity and the culture it is a

part of (Lave & Wegner, 1991; Rogoff, 1993). This general theory of learning has led to the development of apprenticeship models of instruction (Brown, Collins & Duguid, 1989; Collins, Brown & Newman, 1989; Newman, Griffin & Cole, 1989; Palincsar & Brown, 1984). Such models emphasize the need to enculturate students into such things as ways of thinking, problem solving, and comprehending text, often through the use of modeling and scaffolding techniques.

Many science pedagogies (particularly apprenticeship approaches) make use of modeling and scaffolding techniques. However, modeling and scaffolding can be applied to many purposes. In our work, we have been interested in how the apprenticeship model of instruction might apply to the realm of transformative, aesthetic experience. It seems likely that there is a strong social component to the undergoing of transformative, aesthetic experiences because our engagement in such experiences is often associated with membership in a particular community. For instance, membership in the artistic community seems to afford the undergoing of transformative, aesthetic experiences with art, while membership in the scientific community seems to foster transformative, aesthetic experiences with science. Each community enculturates us with particular ways of valuing, perceiving, and experiencing that can transform our relationship with the world. Hence, it also seems logical that classrooms, which function as genuine communities of learners, may also be contexts for enculturating students into particular transformative, aesthetic experiences. In accordance with this assumption, we present some specific forms of modeling and scaffolding that we believe will be effective in fostering transformative experiences. These methods go hand in hand with the approaches to crafting ideas out of concepts mentioned above.

Model a passion for the content. Students first come to experience subject matter concepts through the eyes of their teacher. This puts a great burden on the teacher to portray

subject matter in ways that captivate, motivate, and enervate students to give an honest effort in learning and seeing the world anew. A wonderful example again comes from the movie *Dead Poets Society*. As the character of Mr. Keating, Robin Williams shows what it means to be alive with poetry and literature. It rapidly becomes clear (to the boys and the viewer) that poetry is not just an academic subject for Mr. Keating. Rather it is a vital force that drives his life. Poetry, for Mr. Keating, is a catalyst for transformative, aesthetic experience.

Few of us (if any!) have Robin Williams' talent for expression or even Mr. Keating's passion for the subject matter. But we can certainly seek to be more passionate than we currently are. A study by Brophy and Kher (1986), involving observations of reading and mathematics instruction in middle-grade classrooms, concluded that out of 100 hours of classroom observation only 9 task introductions included information about the meaning, importance, or usefulness of the content to be learned. Further, even these 9 task introductions were so minimal that they were unlikely to convey (let alone foster) passion or interest in the content. Similarly, Newby (1991) coded 1,748 instances of teachers using motivational strategies in 168 hours of observation of first-year elementary teachers, and found that only 7.5 percent of these strategies involved explaining the value of the learning. It appears the we teachers either lack a passion for our subject matter or lack the knowledge/ability to express this passion (as an aside, a comprehensive body of research on teacher passion would be a nice complement to the extensive body of research on teacher knowledge).

What can teachers do to increase their effectiveness in modeling a passion for the content? First, teachers can work on developing a passion for the content in the first place. Teachers are often caught in the dilemma of having to teach content they are not particularly interested in. While this problem cannot be completely avoided, we believe teachers can develop

a deeper interest and passion for the content by engaging in a few simple activities. One of these is to talk with other people about the content. In particular, it is helpful to talk with individuals who are passionate about particular content and find out why they find this content so compelling. Often such individuals will help one see additional meaning and significance in the content. Another thing teachers can do to develop a passion for the content is to spend time going through the process of considering how a concept could be an idea. By going through the steps of crafting ideas out of concepts, teachers may become aware of the significance of the content and how it may enrich everyday experience. Finally, teachers can seek out their own transformative, aesthetic experiences with the content. As teachers try out the content in their everyday lives and use it to see and experience the world in new ways, they will likely find more meaning in the content itself.

A second strategy teachers can use to increase their effectiveness at modeling a passion for the content is to script ways of expressing interest. That is, plan times for and ways of expressing personal interest in the subject matter. This may seem contrived, but in our teaching experiments, we found we often failed to take advantage of opportunities to express our interest in the content. There is such a push to cover content and achieve understanding that it is easy to forget to talk about why the content is interesting and valuable.

Finally, teachers can increase their effectiveness at modeling a passion for the content by regularly taking the time to share their own transformative, aesthetic experiences. This involves such things as talking about their own re-seeing and their own experience of trying out science ideas and using them to appreciate the world more deeply. In other words, it involves showing the students what it means to engage with the content as an idea in the Deweyan sense. For example, Girod (2001) began a 5th grade lesson on molecular motion by stating,

> Last night I noticed that the condensation was freezing on my garage windows. It was making the most interesting and spectacular little patterns of ice crystals. I couldn't help but imagine how the molecules were moving more and more slowly as the temperature dropped, until finally, they formed these amazing little crystals.

In summary, we may not all have the charisma of Robin Williams, but we all can talk about what the subject matter does for us; how the ideas enrich our lives, expand our perception, contribute to the meaning we find in the world, and so on. Doing these things will help create a culture within the classroom where transformative, aesthetic experiences are valued.

The modeling of a passion for the content is not a new idea. Many science pedagogies similarly advocate this notion. Nevertheless, we feel a need to continually emphasize the importance of modeling passion – particularly in the form of modeling one's own transformative, aesthetic experience with the content. If the studies by Brophy and Kehr (1986) and Newby (1991) are any indication, modeling of passion is not a common practice.

Scaffold students' action, perception, and valuing. To further enculturate students into a particular way of seeing and experiencing the world through some content, teachers may also employ scaffolding techniques. Specifically, teachers can arrange a series of activities to help students move from peripheral to more central participation in transformative, aesthetic experiences with the content. For example, in teaching the unit on adaptation mentioned above Pugh (2002) first modeled how he used the concept of adaptation to perceive animals in a personally meaningful, new way. Then, he guided the students in class as they practiced seeing animals in terms of adaptation. Next, he provided opportunities to examine animals through the lens of adaptation while working in small groups. Finally, he encouraged the students to try out this adaptation lens in their own, everyday, out-of-school lives and he provided opportunities for

students to talk to each other about the out-of-school experiences they had of seeing animals in terms of adaptations. Hence, students were supported in moving from listening to the transformative, aesthetic experiences of the teacher to engaging in and in sharing their own transformative experiences. In this way, the classroom community evolved into one that was focused on transformative experience with the content.

Conclusion and Future Directions

This paper presents a view of science education from the perspective of art and aesthetics. Such a perspective places transformative, aesthetic experience at the forefront of educational objectives. But this is not to say that this approach is incompatible with other educational goals. Indeed, the model presented in this paper could likely be combined with science pedagogies focused on such outcomes as inquiry (learning to do science) and conceptual change (constructing more sophisticated understanding of particular principles). Nevertheless, our concern has been with illuminating the artistic side of science. We believe that science, like art, is valuable because it provides an interesting and pleasing way to see and be in the world.

Future research is needed to more clearly articulate and define the methods mentioned in this paper and more empirical research is needed to validate these methods. The model presented in this paper should be taken as an idea in the Deweyan sense. That is, it should be taken as a set of possibilities that need to be tried out in one's own experience. One concern is that this teaching may be too labor intensive. It takes significant time to craft the content in an artistic way, and to develop and model a passion for the content. With teachers' heavy loads and the common practice of teachers being asked to teach outside their main area of interest and expertise, we speculate that it would be difficult for teachers to teach for transformative, aesthetic experiences all the time. Instead, they may need to focus on fostering transformative,

aesthetic experiences with a few concepts and, over time, build a repertoire of methods for teaching concepts in an artistic way. Collaborations between teachers and researchers are needed to explore the dynamics of trying to teach for transformative, aesthetic experience.

We conclude by stating that science education has a great potential to expand and transform experience, but we fear that its transformative and aesthetic potential is not fully actualized. In a data set currently being analyzed by Pugh and colleagues, it was found that only 11 (7%) out of 160 high school biology students reported having transformative experiences in relation to learning about natural selection and adaptation. The vast majority of the students disagreed that they thought out, applied, or were interested in these ideas outside of school. Are these results unique to this sample or are they reflective of the larger population? Based on our own experience, conversations with other science educators, and the general educational climate, we lean toward the latter and speculate that transformative experiences are rare rather than common. Nevertheless, we believe that science education will improve in this area when researchers and teachers alike make a concerted effort to focus on teaching for transformative, aesthetic experience.

References

Brophy, J., & Kher, N. (1986). Teacher socialization a mechanism for developing student motivation to learn. In R. Fledman (Ed.), *Social psychology applied to education.* (pp. 257-288). New York: Cambridge University Press.

Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher, 18(1),* 32-42.

Chandrasekhar, S. (1987). *Truth and beauty*. Chicago: University of Chicago Press.

Collins, A., Brown, J. S., & Newman, S. (1989). Cognitive apprenticeship: Teaching students the craft of reading, writing, and mathematics. In L. B. Resnick (Ed.), *Knowing, learning, and instruction: Essays in honor of Robert Glaser* (pp. 453-494). Hillsdale, NJ: Erlbaum.

Dawkins, R. (1998). *Unweaving the rainbow: Science, delusion, and the appetite for wonder*. New York: Teachers College Press.

Dewey, J. (1933). *How we think: A restatement of the relation of reflective thinking to the educative process*. Boston, MA: D. C. Heath and Co.

Dewey, J. (1938). *Experience and education*. New York: Macmillan.

Dewey, J. (1958). *Art as experience*. New York: Perigee Books (original work published 1934).

Dewey, J. (1988). The quest for certainty. In J. A. Boydston (Ed.), *John Dewey: The later works, 1925-1953* Carbondale, IL: Southern Illinois University Press (Original work published 1929).

Dewey, J. (1990). *The school and society and the child and the curriculum*. Chicago, IL: University of Chicago Press (original work published 1902).

Feynman, R. (1989). "*What do you care what other people think?"* New York: Bantam.

Fischer, E.P. (1999). *Beauty and the beast: The aesthetic moment in science*, translated by Oehlkers, E. New York: Plenum Publishing Corporation.

Flannery, M. (1991). Science and aesthetics: A partnership for science education. *Science Education, 75(5),* 577-593.

Garrison, J. (1995). Deweyan pragmatism and the epistemology of contemporary social constructivism. *American Educational Research Journal, 32,* 716-740.

Girod, M. (2001). *Teaching 5th grade science for aesthetic understanding.* Unpublished doctoral dissertation, Michigan State University.

Girod, M., Rau, C., & Schepige, A. (2003). Appreciating the beauty of science ideas: Teaching for aesthetic understanding. *Science Education*, *87*, 574-87.

Girod, M., & Wong, D. (2002). An aesthetic (Deweyan) perspective on science learning: Case studies of three fourth graders. *Elementary School Journal*, *102*, 199-224.

Greeno, J. G., Collins, A., & Resnick, L. B. (1996). Cognition and learning. In D. Berliner & R. Calfee (Ed.), *Handbook of educational psychology* (pp. 15-46). New York: Macmillan.

Haft, S., Witt, P. J., Thomas, T. (Producers) & Weir, P. (Director). (1989). *Dead poets society* [Motion Picture]. United States: Touchstone Pictures.

Holton, G. (1978). *Thematic origins of scientific thought: Kepler to Einstein*. Cambridge: Harvard University Press.

Jackson, P. (1998). *John Dewey and the lessons of art*. New Haven: Yale University Press.

Johnson, M. (1990). *The body in the mind: The bodily basis of memory, imagination, and reason.* Chicago: University of Chicago Press.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge, MA: Cambridge University Press.

Lorenz, K. (1997). King Solomon's Ring. New York: Meridian. (Original work published in 1952).

McAllister, J.W. (1996). *Beauty and revolution in science*. New York, Cornell University Press.

Newby, T. (1991). Classroom motivation: Strategies of first-year teachers. *Journal of Educational Psychology, 83*, 195-200.

Newman, D., Griffin, P., & Cole, M. (1989). *The construction zone: Working for cognitive change in school*. Cambridge, MA: Cambridge University Press.

Ortony, A. (1979). *Metaphors and thought* (Ed.). Cambridge, England: Cambridge University Press.

Palincsar, A. S., & Brown, A. L. (1984). Reciprocal teaching of comprehension-fostering and comprehension-monitoring activities. *Cognition and Instruction, 1(2),* 117-175.

Prawat, R. S. (1999). Dewey, Peirce, and the learning paradox. *American Educational Research Journal, 36,* 47-76.

Prawat, R. S. (2000). The two faces of Deweyan pragmatism: Inductionism versus social constructivism. *Teachers College Record*, *102*, 805-840.

Pugh, K. J. (2002). Teaching for transformative experiences in science: An investigation of the effectiveness of two instructional elements. *Teachers College Record*, *104*, 1101-37.

Pugh, K. J. (2004). Newton's laws beyond the classroom walls. *Science and Education*, *88*, 182-96.

Rogoff, B. (1993). Children's guided participation and participatory appropriation in sociocultural activity. In R. H. Wozniak & K. W. Fischer (Ed.), *Development in context: Acting and thinking in specific environments* (pp. 121-153). Hillsdale, NJ: Erlbaum.

Root-Bernstein, R. & Root-Bernstein, R. (1999). *Sparks of genius*. Boston, MA: Houghton Mifflin.

Root-Bernstein, R. (1997). The sciences and arts share a common creative aesthetic. In A.I. Tauber (Ed.), *The elusive synthesis: Aesthetics and science*, pg. 49-82. Norwell, MA: Kluwer Academic Publishers.

Stavy, R. (1991). Using analogy to overcome misconceptions about conservation of matter. *Journal of Research in Science Teaching, 28*, 305-313.

Vygotsky, L. (1986). *Thought and language (A. Kozulin, trans.)*. Cambridge, MA: MIT Press.

Vygotsky, L. (1978). *Mind in society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.

Wong, E. D. (1993). Understanding the generative capacity of analogies as a tool for explanation. *Journal of Research in Science Teaching, 30,* 1259-1272.

Wong, E. D., Pugh, K. J., & The Deweyan Ideas Group at Michigan State (2001). Learning science: A Deweyan perspective. *The Journal of Research in Science Teaching*, *38*, 317-36.

Table 1
Methods of Fostering Transformative, Aesthetic Experiences.

Methods of Crafting Ideas out of Concepts
(ideas about how to transform ordinary concepts into compelling ideas that will lead students to see and experience the world in a meaningful, new way)

- Restore concepts to the experience in which they had their origin and significance.
- Foster anticipation and a vital, personal experiencing.
- Use metaphors and "re-seeing" to expand perception

Methods of Modeling and Scaffolding Transformative, Aesthetic Experience
(ideas about how to enculturate students into ways of valuing and experiencing science ideas)

- Model a passion for the content.
- Scaffold students' action, perception, and valuing.