Teaching for Aesthetic Understanding

The Research

Science education has long pointed to scientists and the act of scientific investigation as the standard by which we should measure student inquiry and learning. In one example, it has been argued that scientists employ some method of systematic inquiry and that we should teach our students similar manners of inquiry if they are to develop an understanding of the nature and practice of science. Scientists, however, also discuss the power of science to illuminate beautiful aspects of the world, to foster aesthetically pleasing experiences with the world and to provide generative ideas that help to explain its phenomena. Very little of this discourse has been appropriated by the science education community and this research was designed to do just that. Given the theoretical framework of teaching for aesthetic understanding, derived from an aesthetic theory first articulated by Dewey, could powerful and meaningful learning be facilitated? If so, what are the effects of such efforts? These were the questions that guided the inquiry and the data as described support positive answers to each. A greater number of students reported more varied and more complex perceptions and interactions with the world when learning for aesthetic understanding. These same students also reported greater feelings of interest, and affect in science as well as stronger positive efficacy beliefs, and in some cases, more positive identity beliefs about themselves as science learners. Finally, students learning for aesthetic understanding also appear to learn more and forget less when it comes to conceptual understanding.

In review, major differences existed between the two instructional programs in terms of how the content was crafted (although students took identical tests of conceptual understanding), the relations of power in the classroom including how the teacher shared personal experiences with science and whether or not students were encouraged to share their own experiences, and how activities were designed to either support conceptual understanding, in the case of the control classroom, or to support aesthetic understanding, in the case of the treatment classroom. The differences are subtle yet important and powerful. I wish to share one final example of an important but subtle difference in pedagogical programs. It exists in the context of learning about the atmosphere at the beginning of the weather unit.

On the first day of the weather unit in Ms. Parker's class the students learned about the atmosphere — it was, of course, the first topic covered in their 5th grade science book in the unit on meteorology. The book defined the atmosphere as the layer of gases that surround the earth. It stated that the atmosphere is something like 80,000 feet thick and is divided into 4 major layers: the troposphere, mesosphere, ionosphere, and exosphere. Students recited the names of the four layers, wrote down the thickness of the atmosphere on concept maps they had just begun and moved on. The atmosphere is a central element of weather as it is the weight of the atmosphere that causes air pressure and air pressure, as any weather-channel-watching person can tell, is an important element of weather. I wanted to make sure my students understood that.

On the first day of the weather unit in my class I took my students outside, we lay on our backs in a circle and stared up into the sky. I asked, "Can you see those treetops over there? Can you see those birds flying above the trees? Can you see those low puffy clouds? Can you see above

those clouds to the thin wispy ones beyond? There's depth to the sky — some things in the sky are higher than others. That's because the sky is actually like an ocean of air. Right now you're lying at the bottom of an ocean of air looking back up toward the top through miles of air. There's actually 17 miles of air pressing down on you and your face right now and that air has weight. Air matters." After this little speech, 15 minute long question and answer period followed as students asked questions such as "Why don't we feel the air? What would happen if our atmosphere was twice as deep? And What kind of gases are in our atmosphere?" Students were particularly struck by the metaphor of atmosphere as ocean as five days later (this lesson took place on a Wednesday and the next science day was the following Monday) 11 different students mentioned to me that they had either thought about the ocean of air as they enjoyed their weekend, mentioned the idea to somebody else, and in the case of 2 students, tried to recreate for them the experience of lying on their back and "seeing" up into the ocean of air. Both classes learned about the atmosphere. The control class also learned about the layers of the atmosphere (material beyond the scope of the science curriculum goals) but the treatment class learned in such a way that students were drawn to wonder, tell others, and see the world through new eyes. For me, this brief anecdote captures the essence of the difference between the two instructional programs. However, I will now say more about teaching for aesthetic understanding and specific pedagogical moves useful in doing so.

Four students and their stories

The vast majority of qualitative data comes from student interviews. As described earlier, all students were interviewed prior to any instruction and at the end of the semester; at the conclusion of the third unit of instruction. At two points between these, half the students in each class were interviewed in an attempt to investigate if a) students gained proficiency in their ability to learn for aesthetic understanding, and; b) to investigate the effect of the interview on students emerging aesthetic understanding. It is foreseeable that students may begin to report qualities of aesthetic understanding simply by being asked several times if their perceptions of the world have changed as a result of science learning or if they felt compelled to act or explore their emerging science ideas. Students were chosen at random to participate in these two intermediate interviews. However, the same students were interviewed. All interviews were conducted in pairs based on student ability. This was done to prevent students with vastly different abilities and successes in learning the science content from feeling uncomfortable with one another as they discuss their experiences. The length of the interviews varied from 15 minutes to 40 minutes each.

Two students were selected from each class to represent roughly average student experiences learning science during the course of this research. One boy and one girl were chosen from each class to represent a more balanced view of student experience. The two students from the treatment class, Margie and Tyler, have average scores of aesthetic understanding roughly in the middle as compared to the rest of their class (Margie = 2.67; Tyler = 2.33; class mean = 2.36). Table 5.1 shows their scores as well as the scores of the remainder of the treatment group students. The two students from the control class, Jill and Joe, however, represent students with slightly higher than average scores of aesthetic understanding (Jill = 2.67; Joe = 1.83; class mean = 1.57). I chose students with slightly higher than average scores for two reasons. First, without choosing students with slightly higher than average scores, I'd be left with very little to write

about. Many of the students in the control group rated very low in terms of aesthetic understanding. Although we would expect this, as this is what the treatment is specifically designed to foster, most control group students offered very little substance for such an analysis. Jill and Joe, however, with higher than average scores offer more. Certainly we would expect that if the interview questions were more broad, asking about students general experiences learning science, then perhaps more students would have had more to say. As it was the interview questions centered on investigating aesthetic experiences and most students in the control class simply had nothing to report. Second, particularly in the case of Jill and Margie, whose scores of average aesthetic understanding are equal, the nature of their responses is dissimilar. Their case studies will bear this difference out. I chose Jill, therefore, to purposefully try to "match" the case of Margie. The cases of Margie and Jill are presented first with some discussion of the contrasts between them. The cases of Tyler and Joe are presented next, again, with some discussion of their contrasts. All four students participated in time2 and time3 interviews — another reason they were chose for case study analysis. In summary, students were chosen because they are comparable in terms of quality of their scholarship (prior student achievement, attention to school work, conscientiousness regarding school success), gender, and prior experiences with me as their science teacher.

Margie: Treatment class, emphasis on changed perception

Margie is one of the brighter, more academically conscious students in the treatment class. She listens attentively, completes all her assignments, and turns everything in on time. She appears to value school and works hard to do her best. Although Margie claims she likes science stating, "Yeah, science is pretty neat." She began the year by ranking it as her 6th favorite class behind math, music, art, reading, and PE. Nonetheless, Margie works hard in class and might be considered a model student.

During the previous school year, I taught several science units to Margie's 4th grade class and used some of the same language and activities in trying to get students to come develop aesthetic understandings. Even as a 4th grader Margie gravitated toward seeing or "re-seeing," as a way of enacting her science learning. In the pre-instruction interview at the beginning of the school year (time1) Margie made this comment, "Reseeing made me see things differently than I had before. I unsaw the moon and the water cycle too. Unseeing made me think differently about stuff and I like that." Although one might be tempted to conclude that because of this predisposition toward aesthetic perception Margie should not represent the treatment class as an "average" student. Referring to the table showing treatment student responses to interview questions we see that these concerns do not bear out as 8 other students scored higher than Margie on average per-item scores. Additionally, I will contrast Margie with Jill, a student in the control class who I also taught as a 4th grader and who also spoke of unseeing as powerful at the beginning of the school year.

As we began our unit on weather Margie was quickly taken by the powerful metaphor of "atmosphere as ocean of air" that focused initial instruction. She was one of the students who reported thinking about the ocean of air as she played outside over the weekend and described wondering about how "it's strange that you don't feel all that air pressing down on you." Margie described how she pretended to "swim" around her yard relishing in the experience of imagining

the air around her as liquid water. By the end of the weather unit, however, Margie had begun to describe full-blown instances of changed perception. After having learned that one way to think about weather is that it is simply energy moving around, trying to find equilibrium, Margie described this experience, "My little brother got in a fight with my mom and there was so much energy in our house until he went outside and then the energy went back down. I thought about how that was kind of like a hurricane with lots of energy." Margie began to see hurricanes and violently moving energy where none had existed before.

Across the course of the second unit, in which we learned about erosion, Margie continued to report experiences in which her perception of the world had changed. "When I look around I see erosion now, before I didn't, but now I do. My friend had a rat and it would go behind this little shelf thing and it would go potty behind there. After a couple years of that it made a little dip in the floor which is kind of like erosion from rat potty!" Part of coming to powerful science learning through aesthetic understanding is an increase in the frequency of connections one makes between science ideas and personal, real-world experiences. Students like Margie who report increased frequencies of thinking about and seeing examples of science ideas is important. Additionally, students with high levels of changed perception may also report feeling deeply engaged by their newfound perspective on the world. For example, one afternoon during students' snack time I noticed Margie intently staring at a potato chip she held between her fingers. She was carefully scratching a fingernail down the length of the chip and observing the tiny particles of potato chip falling to her desk. "I was just thinking about how this is kind of like erosion. My fingernail could be like wind or rain or glaciers or something slowly scraping off the land. I'm making erosion!" Although Margie did not report viewing erosion as a war between forces trying to destroy the world and objects resisting destruction as I framed it at the beginning of the unit, she clearly found the idea compelling. Margie offered 6 examples in her post-erosion interview of situations in which she thought about erosion or saw evidence of it.

During the final unit on the structure of matter Margie experienced even more extreme changed perception. The unit was framed in terms of "the dance of the little lumps." This line was taken from a short video we watched in which molecular motion was described as a dance that changes characteristics as energy increases and phases change. Margie described her experience in the bathtub, "I was taking a bath and I had this fizz-ball thing but it wasn't working. It was supposed to fizz but it didn't so I imagined what the molecules were doing. I thought maybe they weren't dancing fast enough so I added some hot water." Later in the same interview Margie described eating a bowl of soup over the weekend. "I was about to take a bite of soup when it hit me how strange it was that the dance in my soup was really going so much that some of the molecules jumped out into the air. I could see the steam rising so I knew there was evaporation. Then I imagined what a boring dance it must be in my spoon." Margie described the molecular organization in three different states — gaseous soup vapor, liquid soup, and solid spoon — in the metaphor of dance. The lens of dancing molecules compelled Margie to help her mother perceive their lunchtime soup differently, "I tried to get my Mom to re-see the soup but she didn't want to."

I believe Margie represents a compelling case in which a student came to see the world differently through the eyes of particular metaphors used to describe scientific ideas. The activity of re-seeing seemed particularly powerful for Margie as she described attempts to do so on

several occasions. The power of Margie's learning does not stop at changed perception. She obviously is moved to explore, investigate, look for examples, and even to teach others what she has learned about science. In fact, Margie was so taken by the metaphor of "ocean of air" that she tried to re-create the experience of coming to appreciate it with her family members. "After we learned about the 17 miles of air I went home and got my little brother and my little cousin to lie down out in the front yard. I told them about the 17 miles of air pressing down on them and how they were at the bottom of an ocean of air."

Jill: Control classroom, emphasis on language of science

Jill and Margie are similar in many ways. Both are good students with high levels of interest and ability in school, both list science as their sixth favorite subject with music, PE, reading, math, and art listed ahead of science, and both learned science from me in the 4th grade. As with Margie, Jill reported re-seeing as a powerful activity learned in the 4th grade "Last year I learned about the moon and how it moves around the earth and that really changed the way I thought about the moon. I learned how to re-see it." Unfortunately, these are the only comments Jill makes about perceiving the world differently through science throughout the course of this research. Although Jill does describe learning science as interesting and offers several examples of how her learning helped her to act in new ways, the quality of Jill's stories are quite different from Margie's.

Where Margie used her science knowledge to see ordinary objects and events very differently, Jill related stories in which she used her science knowledge to verify or confirm her own emerging understanding. When asked if she thought about anything differently at the end of the weather unit Jill had this to say, "Yeah, I think about the clouds differently than I did before. I like to go outside and look at the clouds and try to name them like stratus, cirrus, cumulonimbus and so on. Then I come back inside and get out my science book to see if I was right." The task for Jill seems to be to confirm her knowledge of the terminology of science while Margie almost never uses formal science words to describe her experiences. This trend toward science terminology and confirmation of her own science learning continues with Jill, "I like to go outside and feel the temperature and wind and try to predict the weather for tomorrow. I guess about the fronts, and the highs and lows and then I go look at the forecast in the paper and see how close I am."

Jill's method of learning science by seeking looking for confirmation in the world, checking her understanding, and checking to see if she "right" continue into the next two units. I asked Jill after she learned about erosion if erosion made her think differently about anything or see anything differently than she had before. She had this to say, "I guess I look at sediments differently now than I did before. Before I didn't know that there was clay, sand, silt, gravel and so forth." Again, we see the tendency to report on terminology as clay, sand, silt, and gravel are simply ways to classify the sizes of sediments. Certainly Jill's push to understand terminology is a factor of the values in Ms. Parker's classroom. As described previously, Ms. Parker frequently asks students to use their "science words" and gives assignments that emphasize the language of science rather than powerful ideas and ways of looking at the world as in the treatment class. In this way Jill is quite perceptive in identifying and then adopting the values of her classroom teacher. One could argue that this is the trademark of successful students.

By the end of the third unit I was not surprised a bit when Jill described an experience in which she thought about science outside of class. "My little cousin didn't know about solids, liquids, and gases so I told him all about how the molecules move in each one. I also told my Aunt which metals stick to magnets. She didn't know that either so I had to tell her." Jill's attempts to learn science and personalize its content are consistently grounded in attempts to use the language of science properly and efficiently. Even after having reported on the power of re-seeing at the beginning of the school year, Jill did not report a single incident that could be interpreted as re-seeing in 5th grade science. By the end of the semester, after studying the same three science units, although with different goals in mind, Jill again rated science as her 6th favorite subject while Margie ranked science as her 4th favorite — having moved up ahead of reading and art. Jill appears not to have found the control class science instruction particularly stimulating or interesting. When asked if learning about science had made the world seem a more interesting and more exciting place to be, Jill responded, "Horses and rainbows make the world seem more exciting, not science." This is a profound statement for such a young student and I believe it illustrates a common problem that science teachers, and perhaps all teachers, face. Students rarely find school subject matter interesting or compelling to study (Zahorik, 1996).

Unlike Jill, students in the treatment class responded quite differently to the question of increased interest and excitement. Tyler, for example, seems to find a great deal of excitement in science ideas alone. As with Margie and Jill, Tyler will be contrasted by Joe in the control class.

Tyler: Treatment class, emphasis on excitement and action

Tyler is not a student that I had in class as a 4th grader. If the reader harbored concerns over the effect of my instruction on Margie as a 4th grader Tyler should alleviate them. In the interview before instruction began (time1), Tyler described only one time in which he learned something in science class that proved to be unusually powerful or illuminating. He referred back to this example throughout the first interview as an example of learning that was exciting, causing him to ponder science outside of class. His exact words were, "Well, one time I learned about pigs' eyes and I thought about how my eye was pretty much the same." Needless to say, Tyler's example is less than overflowing with intensity, enthusiasm, and vigor. Across the course of this research Tyler began to report more engaging science learning.

After learning about air pressure at the beginning of the first instructional unit Tyler reported, "I thought about the 17 miles of air pressing down on me — that was cool to think about when I was walking around. It made me feel strong!" From this first day of learning for aesthetic understanding Tyler demonstrated a knack for getting the most from metaphoric descriptions. Later during the weather unit, as we framed violent weather as energy searching for equilibrium, Tyler made this metaphoric connection, "Just like when you eat food and the food breaks down into energy and that energy starts to move around inside your body — that's just like the weather — the energy gets moved around." Upon further exploring his connection to digestion it was apparent that Tyler grasped the notion that "ingredients" make up weather just as "ingredients" make up food and these ingredients have the potential to unleash energy in the form of glucose or ATP in the case of digestion, or hurricanes, tornadoes, and thunderstorms in the case of meteorology. "Weather as energy" helped Tyler make a connection to something he knew about

— digestion. This is an excellent example of how metaphor can be used to bridge the gaps in our understanding and help us to see phenomenon through different eyes and make new connections in our understanding.

Tyler seemed to have his most powerful learning experiences with our study of erosion. Tyler reported 6 instances in which he thought about, noticed, or sought out evidence of erosion in his life outside of school. "I was walking home and I saw grass growing up through the sidewalk. I could see the little roots and I could tell they were causing erosion. Then I kept walking and I saw a big hole, kind of like a ditch, and it was all rocky and wet and the water was all filled up in it and I thought about how it was making erosion down there." In an effort to elicit responses from the other student with which Tyler was being interviewed the interviewer stopped Tyler from continuing to tell another story about erosion. After listening to his fellow interviewee for about 30 seconds Tyler stated excitedly, "Hurry up! I've got more to talk about. I could go on about erosion for days!"

Toward the end of the interview Tyler was asked why he believed learning about erosion proved so powerful for him. He attributed his enthusiasm to me claiming "Mr. Girod tells us about erosion. He says 'EROSION BABY!'" excitedly gesturing as I had apparently done in class. It seems reasonable that Tyler derived a sense of motivation and engagement through my dramatic teaching style but I would like to offer a different explanation. As articulated earlier, Tyler seems adept at connecting metaphoric ideas presented in class to his own experiences and emerging conceptual understanding. After a short walk around the school building to look for examples of erosion, Tyler stated quite mater-of-factly "On the trees, the fungus is like erosion." When pushed to expand on his idea he stated, "Fungus eats trees and if there's too much fungus it can kill the tree. That's like erosion." Again, although fungus on trees is not exactly analogous to erosion as there is no moving away and re-deposition of sediments but the idea is not without parallels to erosion. Fungus breaks down tree bark just as rain wears down rocks and fungus will, if left unchecked, potentially kill the tree just as rain, if left to do its work, will eventually completely wear away a rock. Once again Tyler successfully translated ideas into his own world and found them to be generative and compelling.

Tyler did not report on learning experiences quite as enthusiastically during the final unit on structure of matter. Although Tyler did report several instances in which he thought about molecules he only reported one extensive story to illustrate his learning. "One day in the summer we had a little family reunion sort of. My family, they always eat chocolate and they leave it around outside and the chocolate melted inside their cups so they put it in the refrigerator to freeze it back into a solid. I was thinking about the molecules and how they were dancing when they were solid and then liquid and then solid again. I didn't tell anybody about what I was thinking about. I thought it was cool that I knew and they didn't."

Tyler's experiences all seem important and powerful for him as a science learner. Perhaps, though, the most compelling piece of evidence that suggests learning for aesthetic understanding helped Tyler to learn in ways different and more powerful than he had before comes from a story he told after learning about the weather. "I also have some weather machines at home that I bought when we studied weather. I built a little cubby to put my computer in so it doesn't get when I go outside. I check the weather and use my weather instruments. Our weather unit kind of

changed my life like that. I tell my mom and dad what the weather is going to be like — I'm like the weather person in my family." Unfortunately the interviewer did not ask Tyler to expand on his claim that learning about weather changed his life. Regardless of his response to such a probe, such a claim is high praise for any learning. Knowing Tyler, I suspect he found an area of knowledge in weather in which he could demonstrate his expertise for his family. It seems likely that this made him feel good as both a person and learner. During each post-instruction interview (time2, time3, and time4) Tyler gave the same response when asked why he felt compelled to tell his family what he was learning, "I like to tell them because they don't know. It makes me feel smart. It makes me feel good." Arguably, science may not be the school subject matter most likely to engender efficacious feelings and positive identity perceptions but, at least with Tyler, this seems to be the case and the result is quite significant. Chapter 5 examines these questions of efficacy and identity statistically. Tyler is now contrasted with Joe who seems to derive his enthusiasm from more instrumental values.

Joe: Control class, emphasis on instrumental value

Joe was also a student of mine as a 4th grader. Perhaps because of this he reports initial levels (time1) of changed perception, action, and excitement regarding science learning at a higher level than the class average. In fact, before instruction began in the fall I asked Joe why a kid might want to learn science, Joe responded, "A kid might want to learn science to learn something interesting." His response was provocative because it seemed to imply that other subjects were somehow less interesting. In an effort to explore this I asked three other students the same question. All three children responded with instrumental explanations — "so he can do good in high school," "so he can be a scientist later," and "so he can get a job." Like Jill described earlier, Joe seemed well situated to continue to learn science in powerful and aesthetically pleasing ways — ways other than purely for instrumental purposes. Unfortunately this was not the case.

Because my conversation with Joe reported in the preceding paragraph occurred before any science instruction had taken place, it seems possible that Joe was still operating under the assumption that what was valued in science were things like expanded perception and being swept up with interest and enthusiasm — qualities valued in the previous year when I was his teacher. After the first unit in which Ms. Parker taught it must have become apparent to Joe that the values had changed. When asked if he had learned anything unusually interesting or exciting during his study of weather Joe reported, "I think probably learning about the clouds was the most interesting thing we did. I learned all the names of them." As with Jill we see the act of labeling and naming as the most salient and meaningful activity. The treatment class students reported power in expanded perception and the control students reported power in labeling and naming — what's important about this difference is not which activity is better but that they are simply very different activities — one instrumental in nature the other experiential.

As instruction continued Joe maintained this new-found instrumentalist position toward science learning. "I used to wonder what clouds were made of but now I know they're just made of water vapor" and "I first thought erosion was about gravity and weather but then I learned it could be about lots of other things too." We see a glimpse of Joe as a "wonderer" but his wonderment is used to answer very practical questions — what are clouds made of and what factors affect

erosion. By the time Joe was interviewed at the conclusion of the third science unit (time4) he didn't mention a single instance in which he felt his learning to be powerful, generative, or even particularly interesting. I asked him, for example, if he had tried to learn more about the structure of matter and molecules on his own. Joe responded, "I suppose a person could check out a book on that stuff but I wouldn't. I don't care about it." His comment here, at the end of the third unit, is remarkably similar to a comment made at the conclusion of the second unit, "Erosion isn't too exciting. I do get excited about other stuff like math. I see numbers all over and I'm always counting things in the car when we're driving along. Science doesn't do that for me." It seems as though although Joe arrived with examples of powerful science learning from his past he failed to report anything particularly powerful during the first half of the 5th grade. Additionally, it is not as though Joe is simply not inclined to be moved by science learning as his comments before instruction indicate otherwise. Also Joe admits that mathematics learning has a powerful effect on him but science, at least as a 5th grader, taught for a goal other than aesthetic understanding, does not.

In my opinion the most interesting difference between Tyler and Joe is the reasons they offer for why science is or is not powerful for them. As discussed earlier, Tyler's reasons are largely egocentric — science makes him feel smart, like a scientist. Joe's reasons are largely instrumental in that science gives him words to describe the world and his experiences in it. Again, the difference can be chalked up to a difference in the held values of the classroom and its pedagogy.