

## Ambiguity and Uncertainty

"One must have chaos within to give birth to a dancing star." Friedrich Nietzsche

Science classrooms that focus on scientific inquiry have many characteristics that differentiate them from conventional science classrooms. The very nature of inquiry suggests that answers to scientific problems must be developed, rather than discovered fully formed. In an inquiry-based classroom, a variety of conclusions may all be equally valid or invalid, based on evidence that may be very credible, not credible, or rather credible. Many students expect absolute truths from their learning experiences, and may find themselves overwhelmed with choices and the uncertainty that comes from wrestling with authentic scientific issues. Ambiguity, however, is not only a feature of inquiry-based science communities, it is necessary if the classroom is to mirror the world of practicing scientists.

Curiosity, one of the practices essential for scientific inquiry, requires tolerance of ambiguity and seeking out the novel and unusual. Curious students embrace ambiguity and are less nervous in uncertain situations (NCREL, 2003). They also have more mental flexibility and "tolerate the discomfort of an ambiguous situation long enough to find out the appropriate solution and/or interpretation" (Stoychevy, 1998).

Ambiguity is also a necessary characteristic of an environment that nurtures creativity. Sternberg and Williams (n.d.) describe the role that ambiguity plays in creativity:

A creative idea tends to come in bits and pieces and develops over time. But the period in which the idea is developing tends to be uncomfortable. Without time or the ability to tolerate ambiguity, you may jump to a less than optimal solution.

Developing scientific theories and models through inquiry is, at its base, a problem-solving process. Students ask questions, design ways to investigate phenomena, and then draw conclusions based on evidence. Solving these kinds of problems demands that students think of creative ways to represent problems and test theories, and they must perform these tasks in situations with no fixed answers, just carefully conceived processes and ingenuity.

Teaching students to feel comfortable in ambiguous situations is critical for success in an inquiry-based classroom. Yet some students cannot be expected to welcome this new environment without support and instruction.

## **Risk-Taking**

To take risks, students need to trust each other and the teacher. Students know when a teacher is asking an open-ended question with a preferred answer in mind or if there are actually a variety of acceptable responses. Students also are more likely to take risks when they have confidence that the teacher is sending them in a direction where they will learn something, rather than setting them up to fail to make a point.

Teachers can support risk-taking in small ways, building up to more substantial ideas:

- Ask open-ended questions and accept all responses.
- Encourage students to think beyond the obvious and share ideas that are not fully formed.
- Make light of errors students make when they try something new, such as using a different kind of software or tool.
- Allow students to correct mistakes without penalty.
- Share stories of successes and failures by individuals that students admire, especially scientists and yourself.

## **Less Emphasis on Grades**

Sadly, for many students, the goal of school is grades, not learning, and they often do not see a connection between the two. Refocusing student activities on learning by helping students develop self-efficacy and responsibility for their own learning can reduce anxiety about grades. Of course, this strategy works only if students have real opportunities to take control of their learning, to address their individual needs, and to get the instruction they need to improve.

Deemphasize grades as much as possible to focus on learning:

- Minimize negative consequences for failure.
- Use frequent formative assessment to allow students to stay informed about how well they are doing and focused on meeting learning goals.
- Require reflections where students use rubrics to describe their progress in inquiry practices and science content, to help them see how their performance compares with expectations and give them concrete information about how they can do better.

## Process over Product

Emphasize processes over products (Langer, 1989). When students use effective inquiry practices, they learn scientific content as well as strategies and processes they can use throughout their lives. By focusing on improving their processes by using checklists and feedback to solve complex problems, students develop the ability to move forward in ambiguous situations. They can think about how to address a difficult situation rather than trying to envision a possible solution.

## Strategy Instruction

Some students develop strategies for solving problems and self-management on their own, but all students benefit from explicit instruction in learning processes. (Pressley & Harris, 1994). Self-directed learners have internalized strategies they can use to manage their own learning. Providing instruction in a variety of processes that students can use to organize their time, keep track of their materials, and get help when they need it helps make them independent.

Teachers must be careful when choosing processes for instruction to think of all kinds of learning styles. Making lists and keeping a calendar may work for some students, but other students may use other methods, such as visualization or digital reminders to keep track of tasks and ideas. Discussions are a good way to elicit useful self-direction strategies from students.

## References

- Langer, E. D. (1989). *Mindfulness*. New York: Merloyd Lawrence.
- Pressley, M., & Harris, K. R. (2009). Cognitive strategies instruction: From basic research to classroom instruction. *Journal of Education*, 189(1/2), 77– 83.
- Sternberg R., & Williams, W. (n.d.) *Teaching for creativity: Two dozen tips*. Retrieved from the Center for Development and Learning Web site:  
[www.cdl.org/resource-library/articles/teaching\\_creativity.php](http://www.cdl.org/resource-library/articles/teaching_creativity.php)
- Stoycheva, K. (1998). *Ambiguity tolerance: Adolescents' responses to uncertainty in life*. [Research Report.] Johann Jacobs Foundation of Switzerland. Retrieved from [www.eric.ed.gov/PDFS/ED422547.pdf](http://www.eric.ed.gov/PDFS/ED422547.pdf)