HUFF POST EDUCATION

**Arthur Camins**
Director, Center for Innovation in Engineering and Science Education, Stevens Institute of Technology



# Arguing for Science Literacy

Posted: 06/02/2014 2:56 pm EDT | Updated: 06/02/2014 4:59 pm EDT

Students who are scientifically literate know how to argue. However, current education policies undermine rather than advance this vital academic goal.

I do not mean disagreements that are resolved based on personal considerations or positional authority. For scientists, argument is all about whether claims -- regarding the accuracy and generalizability of their models to explain the natural world -- are supported by reason and evidence. There are two crucial features of these arguments. First, before knowledge is accepted as proven by the larger community of scholars, valid arguments must be supported by relevant and sufficient evidence and include verifiable rebuttals to counterclaims. Second, scientific arguments are not immutable. Without these two foundational ideas we could neither act nor make progress.

Obscure and relevant only in research labs and academia? Quite the contrary! Argumentation is prominent in both the Common Core State Standards for Mathematics (CCSS-M) and the Next Generation Science Standards (NGSS). It is considered a core "practice" and, therefore, one that is a vital component for every child's learning.

The math standards call for students to begin work on argumentation in kindergarten and continue to gain expertise through high school. For example, in early grades, as students begin to gain facility and experience with manipulating quantities they are encouraged to look for patterns. Students may be asked to consider the following:

7 + 1 = 8 and 1 + 7 = 8
3 + 4 = 7 and 4 + 3 = 7

Students notice that reversing the addends does not change the sum. The teacher may ask, "Can we make that a rule because it works every time? What is your evidence? Can anyone find an example when it does not work?" This is the foundation for argumentation. In classrooms, this practice supports use of evidence and invites reasoned critique.

The CCSS-M Practice, "Construct viable arguments and critique the reasoning of others," builds not just computational skill and understanding. It nurtures an intellectual and social disposition toward reasoning in students' own thinking, while requiring them to consider the reasoning of others.

By high school, in science, students are expected to reason abstractly and gather evidence from multiple sources. Not only are students expected to make and defend arguments based on evidence, but also be able to evaluate when and why some models work in some circumstances, but not others. For example, a NGSS Performance Standard requires students to be able to, "Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other."

In both the early grade mathematics and high school science examples, the arbiter of proof or validity is not the authority of the teacher or the rule stated in a text, but rather the evidence students uncover. Importantly, the goal of scientific and mathematical arguments is not winning a competition but rather reaching the most widely applicable explanation or solution. To be sure, the claims of scientists and mathematicians over the centuries matter, but only because some of their arguments have withstood evidentiary challenges, while others have been refuted or modified.

Developing the ability to engage in reasoned argument is essential for developing students who have the inclination and skill to enter a workforce that depends on scientific, technological and mathematical literacy. It is also equally important for personal relationships and democratic participation. Values matter too. However, values without reason often lead to demagoguery.

There are several conditions that support the development of students' argumentation expertise.

1) Students who learn to be confident that their ability to "get smart" is not a fixed trait, but instead a malleable capacity that they can grow as a result of effort, are better able to engage in argumentation and persist through difficult intellectual work.
2) Students who learn to see failure as a source of new learning rather than a judgment are more willing to listen to others and recognize errors– preconditions for gathering sufficient evidence and consideration of rebuttals.
3) Students who are encouraged to be motivated by truth seeking rather than by competition are more likely to develop the crucial disposition to change their minds in the light of new evidence.
4) Students who learn to collaborate with others in their search for solutions to meaningful personal and social challenges are more likely to be successful in relationships, work and as citizens than those who focus on self.

Current education policies interfere with establishing these conditions for successful STEM learning. First, because assessments are inextricably linked to high-stakes consequences, teachers and students are apt to think about tests as the goal of learning -- and fear them -- rather than embrace opportunities to demonstrate progress and learn from error. Second, performance pay linked to students' testing success fosters competition among teachers for rewards rather than collaboration to collectively meet students' needs. Third, supporters of current education policies violate the basic framework for scientific argumentation, setting a bad example. They have failed to take seriously the evidentiary challenges to their policies while refusing to consider that they may be mistaken and change course. It is time to back away from high-stakes testing induced fear and competition and instead embrace learning from failure and collaboration.

*Arthur H. Camins is the Director of the Center for Innovation in Engineering and Science Education at Stevens Institute of Technology in Hoboken, NJ. The views expressed in this article are his alone and do not represent Stevens.*
*Arthur's articles can be found at http://www.arthurcamins.com*
**Follow Arthur Camins on Twitter: www.twitter.com/arthurcamins**