Iowa Science Teachers Journal

Volume 38 | Number 3 Article 3

2011

Holding Ourselves to a Higher Standard: Using Standards-Based Grading in Science as a Means to Improve Teaching and Learning

Jesse Wilcox
Iowa State University

Holding Ourselves to a Higher Standard

Photo by Jeff Hire

USING STANDARDS-BASED GRADING IN SCIENCE AS A MEANS TO IMPROVE TEACHING AND LEARNING

Jesse Wilcox, Iowa State University
Ames

ABSTRACT: Standards-based grading (SBG) has grown in popularity over the past few years. However, many teachers wonder why they should switch from a traditional grading system. This article explores how standards-based grading can more accurately reflect what students learn and encourage changes in students' attitude toward learning in the process. *This article promotes Iowa Teaching Standards 1, 4, 5, 6, 7, and 8.*

I am passionate about teaching and love when students learn new things. When it came to assignments, however, I have often been frustrated with the lack of personal accountability and self-advocacy of some of my students. I attempted to extrinsically motivate students to care about their learning by having a strict late work policy that I thought would "teach responsibility." Yet, I noticed that the students with missing assignments at the beginning of the year were the same students with missing assignments at the end of the year. If my strict policies taught responsibility, this should not be the case (Kruse, 2010). Furthermore, when some of my students got behind, they all too often gave up. I realized I wasn't really teaching responsibility. My policies and grading practices were at best teaching compliance, at worst a hatred of science. The fundamental question I began to wrestle with was, "How can I use assessment to teach students to be better learners?"

What do assessments typically teach about learning?

When teachers are asked what goals they have for students, the results are much the same (Penick & Bonnstetter, 1993; Clough, 2006). Teachers want students to be creative, problem-solve, communicate effectively, and be self-reliant. We crave the same goals for students, yet the tasks we give and the systems we use to assess teach students a very different message.

Traditional systems of grading have typically focused on what a student does or does not do on a given task. Consider the grading rubric for a cell brochure project in Figure 1. The intent of such a task is typically to teach how the structure of the cell indicates the functions necessary for life. When the rubric is considered, the dominant expectation of students is to include "8 or more items" without making too many spelling or grammatical errors. The rubric doesn't match the intent of the task. As a result, the "learning" occurring does not match our goals for students. Instead, students very quickly come to understand that "learning" is about completing the task while avoiding making too many mistakes rather than a process through which deep connections among ideas are made.

Identifying the fundamental science ideas

If we want students to deeply learn science content, we have to decide what is fundamental. The Next Generation Science Standards, Iowa Core, and National Science Education Standards can provide an important starting place, but are not sufficient. For example, one of the standards for the Iowa Core is "Understands and applies knowledge of motion and forces." While the knowledge is clearly fundamental to understanding science, assessing a statement with so much breadth and depth would be difficult.

When developing the specific ideas being assessed in the classroom, they should align with the documents listed above, but must be more specific. At the school in which I teach, we call these more specific fundamental ideas "learning targets." The learning target is more specific than the state or national standards and is what we are actually using to assess student knowledge. Figure 2 provides an example of specific electricity learning targets assessed in the science classroom that fall under the overarching Iowa Core standard of motion and forces.

FIGURE 1

Example of a traditional grading rubric that emphasizes task completion instead of assessing understanding.

Organelles described in your brochure	**2 points** Only described 1-2 cell parts or processes.	**4 points** Only described 2-4 cell parts or processes	**6 points** Described 4-6 cell parts or processes.	**8 points** Described 6-8 cell parts or processes.	**10 points** Described 8 or more cell parts or processes.
Accurate descriptions of parts/processes using analogies	**2 points** No analogies at all. Simply stated accurate cell part functions in text.	**4 points** 2-4 accurate descriptions using analogies.	**6 points** 4-6 accurate descriptions using analogies.	**8 points** 6-8 accurate descriptions using analogies.	**10 points** 8 or more accurate descriptions using analogies.
Mechanics on all written material	**2 points** More than 7 types of grammatical errors, misspellings, punctuation, mechanics, etc.	**4 points** 5-6 types of grammatical errors, misspellings, punctuation, mechanics, etc.	**6 points** 3-4 types of grammatical errors, misspellings, punctuation, mechanics, etc.	**8 points** 1-2 types of grammatical errors, misspellings, punctuation, mechanics, etc.	**10 points** Grammar, spelling, punctuation, and mechanics are correct. No errors in text.

Shifting the focus to the learner: Standards-based grading

If we want our students to change, we as teachers need to change. We need to move from teaching chapters in a book to teaching fundamental science ideas. The focus of our assessments needs to shift from how much students can produce to how deeply students learn. A way to begin to change ourselves is by changing how we assess. Standards-based grading (SBG) can help teachers move to assessing the fundamental ideas. In SBG systems, student grades are based on their ability to demonstrate knowledge of course/unit standards. SBG allows students to demonstrate understanding of standards in a variety of ways and at a variety of times. Importantly, SBG systems place emphasis on student understanding rather than students compliance (i.e., turning in homework, making sure a paper is three pages long, etc.). Such systems require that teachers must determine the fundamental ideas before the unit begins.

When I started down the road of developing learning targets for the curriculum I teach, I struggled to get started. Through some trial and error, I found by developing a concept map of the unit, I was able to figure out which ideas were the most important and which ideas were details. I have seen others have success by writing a number of questions they might ask students during a unit and condensing those questions into the fundamental ideas. Regardless of how you choose to develop the learning targets for a unit, a number of guiding principles can be used to develop learning targets for any unit of study.

Guiding Principle #1: When writing learning targets, teachers must always stay focused on the learner.

When deciding upon the fundamental ideas of a unit, consider the following:

- What do the students know coming into the unit/class?
- What concepts or ideas are worthwhile for students to deeply understand?
- What concepts or ideas are developmentally appropriate for the age of the students you teach?

FIGURE 2
Electricity Learning Targets with example assessment questions

Electricity Learning Target #1
What is electricity?
- What causes static electricity?
- How does current electricity work? (batteries, bulbs, wires, etc.)
- How is it different than current electricity? How is it similar?

Electricity Learning Target #2
What affects the amount of charge on an object?
- How can you get more or less static charge on something?
- How do materials affect the charge?
- How does the distance the objects are from each other affect the static?

Electricity Learning Target #3
How do charges move between objects?
- What are the different ways objects get a static charge? What is an example of those?
- What causes lightning?
- How does a Van De Graff generator work? Why didn't it hurt us when we touch it, but it shocks us when we don't?

Electricity Learning Target #4
What causes objects to attract and repel?

Electricity Learning Target #5
How does static electricity affect your everyday life?
- Why is there more static in the winter?
- Why do clothes in the dryer have more static when they are dry than when they are wet?
- How would society be different if we had never studied static electricity?

Electricity Learning Target #6
How do circuits work?
- What is the difference between a parallel and a series circuit?
- How do electrons move within a circuit?
- How does a light bulb work? How does a battery work?
- What do you need in order to set-up a circuit? Why are those components necessary?

Nature of Science Learning Target #11
How does science and culture influence each other?
- How has the invention of electricity affected our culture both positively and negatively?

Inquiry Learning Target #1
Design and conduct scientific investigations
- Students are able to design and conduct valid scientific investigations based off of their prior knowledge.

Inquiry Learning Target #2
Analyze and interpret information
- What do you think your data means to you?
- How can you use this data to defend an argument?
- Students use evidence to justify their claims from an activity/lab/etc.

Guiding Principle #2: Learning targets need to be fundamental science ideas.

Learning targets need to be broad enough to ensure the ideas being assessed are fundamental, but specific enough to have success assessing them. In geology, we typically want students to understand how plate tectonics affect Earth. We could write a learning target such as, "How does energy influence Earth systems?" For students who are towards the end of their high school experience, this question may be appropriate. If we made the learning target more specific, we can better assess what students know. For example, "How does convection cause plate motion?" This learning target is much more focused, but is still open ended. However, we could go too far and make the learning target too specific such as, "What are the layers of the Earth?" While plate tectonics is greatly influenced by the density and interactions of magma through the layers of Earth, the responses students would write to this last learning target would be simple trivia. If our learning targets are too specific, we end up teaching and assessing for memorization instead of deep understanding. We have to be sure the learning targets we are using to assess students' knowledge reflect fundamental ideas in science. Striking the balance between too specific (trivia) and too broad takes time and reflection (Figure 3).

FIGURE 3
Learning Target Examples.

Move **away** from trivial and vague learning targets such as:	Move **towards** learning targets such as:
Identify a synthesis reaction.	How do atoms bond?
What are the layers of the atmosphere?	How does the Sun affect the weather we experience on Earth?
Define a volt.	How do electrons moving in a circuit relate to electrical power?

Guiding Principle #3: To guide students, learning targets are often best written in the form of a question.

I quickly figured out the value of putting the learning targets in question form after a student teacher of mine handed students a document at the beginning of an inquiry investigation regarding the conservation of mass. The students soon realized the learning target stated, "Students will understand mass cannot be created or destroyed." Our well-planned inquiry lab suddenly turned into a verification lab! I have chosen to write each of the learning targets in the form of a question because I want students to investigate, debate, decide, and come to a consensus as a class.

<u>Guiding Principle #4</u>: The learning targets should build upon each other and become more complex as the unit progresses.

When we decide to assess learning targets in a logical sequence, we must teach them in the same logical sequence. When a unit is structured effectively, it will make more sense to students because individual lessons naturally link together and build upon themselves.

With any of these guiding principles, we need to thoughtfully consider what we want the students to learn first and then determine how to assess if they have learned it. "Teachers can gain meaningful information about what students know, but teachers have to have clear and concise standards" (Scriffiny, 2008). Once the learning targets are established, we can better know what our students know (and don't know).

Knowing what students know

Teaching would be so much more individualized for students if we knew exactly where they were stuck. Since we can't read students' minds, we have to rely on assessment in order to access student thinking. The way we choose to assess students communicates not only what we value as knowledge, but influences our ability to access student thinking.

Traditional points-based assessment systems fail to provide an accurate indication of student understanding because they often assess student behavior and memorization (Clymer & Wiliam, 2006/2007; Winger 2009). "The system [of grading] must not allow students to mask their level of understanding with their attendance, their level of effort, or other peripheral issues" (Scriffiny, 2008). Winger (2009) points out the message teachers send to parents and students by current grading practices is that "compliance is the priority, and grades have little to do with learning."

Our grading practices should reflect our values. If we value deep learning, our assessments should involve application, relevance, and enduring knowledge. Clymer and Wiliam (2006/2007) put forward three ideas for assessing of deep understanding through standards-based grading.

#1: "The information we collect on student performance has to be instructionally meaningful." Why would we collect information on student performance we won't use? If we give out only meaningful assignments and assessments, we will have less meaningless paperwork to grade and more time to provide feedback on the meaningful assessments (Scriffiny, 2008).

#2: "Assessment systems should be dynamic rather than static." Students should have the opportunity to go deeper with the content even after the assessment and improve their grades if their understanding is truly deeper.

#3: "In a genuine standards-based assessment system, teachers need to assess and record what a student can actually do." We have to decide if we want to assess students' compliance or what students' know and are able to do.

In Practice: Assessing, Feedback, and Reassessing

While the ideas above may make a great deal of sense, how do we practically assess students in such a system?

Assessing Student Thinking

Formative Assessment

In an effective SBG system, formative assessments occur every day in the science classroom. Such assessments include, but are not limited to: open-ended questions posed by the teacher or students, bell-ringer activities, think-pair-shares, white-boarding, and inquiry labs. During any classroom activity, an effective teacher carefully listens to students and scaffolds students' thinking through questioning from their current understanding towards contemporary scientific ideas. The formative assessment process should inform the teacher of current student thinking and therefore guide the teacher's decisions for future lessons. In addition, the student interactions during classroom discussions and activities push students to grapple with fundamental scientific ideas.

Because students are in the process of learning the fundamental ideas through classroom activities, formative assessments should be graded differently than summative assessments. In our school, formative assessments were used to guide instruction and therefore were rarely assigned a grade. If graded, scores were based on the depth of student responses and thoughtful student reflection rather than "the correct answer." As the school year progressed, students became more willing to share their thinking, which in turn resulted in a more authentic learning environment.

Formative assessments, which we called "daily work," were a part of our grade book, but comprised 10% of the overall grade. Alternatively, some teachers in the SBG system chose to avoid assigning grades to formative assessments, but often still kept track of students' progress between summative assessments.

Summative Assessment

Summative assessments in an SBG system attempt to ascertain how well students understand fundamental scientific ideas as well as how well they could apply their understanding to new situations. In my classroom, I used a variety of summative assessments including: projects, laboratory write-ups, quizzes, verbal quizzes with the teacher, and lab practical experiences. Figures 4 and 6 provide excerpts of assessments from a laboratory write-up and quiz, respectively. Regardless of the summative assessment used, the assessment questions should be aligned to the learning targets. As the learning targets are intended to communicate what the student understands, they should comprise the majority of students' grades. In our school, summative assessments of the learning targets were 90% of the overall grade.

FIGURE 4

Excerpt of a learning target and assessment questions from a physics project:

- What is friction?
- Why does friction happen? (Provide detail here).
- How did the modifications and materials you chose reduce the friction in the car?
- Why is it important to reduce the friction in the car?
- Why is some friction important for the car?
- How does friction affect the motion of the car?

Feedback and Evaluation

Assessing in the SBG system is different than assessing with traditional grading using points. In the traditional point based system, points are arbitrarily assigned for each part of their answer. The SBG system requires looking at the overall student knowledge compared to the learning target (see an example of a general grading rubric in Figure 4). Students receive one score for each learning target corresponding to their current level of understanding as well as written feedback for each learning target on how to improve (Figure 5). That is, multiple questions could be asked under a learning target (as they are in Figures 4 and 6), but only one score is recorded for each learning target.

I have found a great deal of success in using the grading rubric in Figure 5 to develop feedback for students. When assessing student answers, I read the student responses and record any errors/omissions on a blank copy of the assessment or in a word document. The errors/omissions are compared to the rubric in Figure 5. I then decide which level of understanding best matches the student's response. Because I am recording my decisions, if another student makes the same errors, they receive the same level of understanding from the rubrics. Finally, feedback in the form of questions is written next to the level of understanding. An example of this feedback process is shown in Figure 6.

When students receive extensive feedback on how to improve, learning becomes dynamic, interactive, and on-going. I have experienced greater success in communicating with my students about their understanding in class and have seen them grow dramatically as learners in the process.

Tips from the Author:

- Developing meaningful feedback does take time, but if I only give out meaningful assignments, I have more time to provide the feedback.
- I have also developed numerous time saving strategies such as typing feedback for students instead of writing them. I can often copy and paste the feedback questions instead of writing them numerous times.

Reassessing Student Thinking

If fundamental science ideas are worth teaching, then why would student learning stop after the summative assessment? We as teachers should relentlessly pursue deep learning for all of our students. Consequently, students in the SBG classroom can continue to learn science concepts after the summative assessment is over.

In my classroom, students take the feedback they received from the assessment and use it to improve their

FIGURE 5

Standards-based grading rubric for learning targets.

Standard Score	**Missing or Incomplete**	**2**	**2.5**	**3**	**3.5**	**4**
Level of Understanding	Cannot Assess	Beginning	Developing	Capable	Strong	Exceptional
Teacher Language	Student did not turn in work or complete the work.	Demonstrates little understanding alone, but partially understands with help.	Demonstrates partial understanding with significant gaps and minimal application.	Demonstrates understanding with minor gaps with little application. No major errors or omissions present.	Demonstrates understanding, but has little application and/or a few minor errors.	Demonstrates a complete understanding through applying their knowledge.
Student Language	I didn't do this standard.	I need LOTS of help!	I need some help.	I have some questions.	I'm almost there.	I understand this very well and can apply it to new situations.

understanding. When they understand the learning target more deeply, they sign up to reassess during my free times (Figure 7). When a student arrives, I ask them which learning target they are attempting to reassess. The student then shows me his or her initial assessment for that learning target along with the feedback I provided. At that time, I determine if a written response or verbal response is more appropriate. I most often use verbal reassessments by having students respond to my questions. Students often choose to supplement their responses with drawings and props (e.g., tennis ball to symbolize an atom).

Value-added with SBG

Communication with SBG

Interacting with students is a critical component of effective teaching. I have always tried to extend the classroom conversation with students by giving extensive feedback on

FIGURE 6

Quiz questions with feedback.

Excerpts from a Chemistry Quiz:

Chemistry Learning Target 5: How do ions (charged atoms) bond?

Score	1	2	2.5	3	3.5	4
Meaning	I didn't do the standard.	I need LOTS of help!	I need some help.	I have some questions.	I'm almost there.	I understand this very will in all situations.

9. Write the chemical formula of the ionic bond that Magnesium (Mg) and Oxygen (O) form.

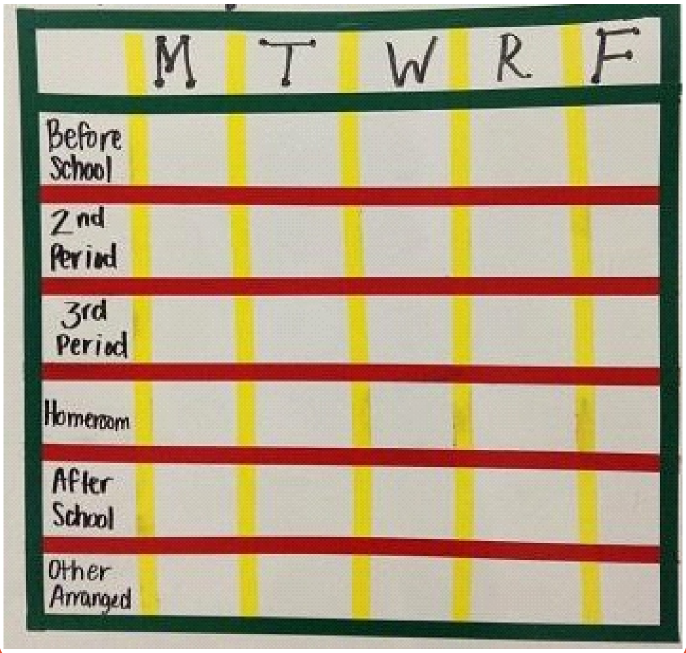
10. Why do atoms bond together?

Examples of Feedback for Chemistry Learning Target 5

Student	Student Error / Omission	Student Level of Understanding	Possible Feedback for Student
Student A	#10: Student wrote about valence electrons, but neglected how movement of electrons causes charges and attraction between atoms.	3.0 (student has difficulty applying how atoms bond)	When an atom gives or takes electrons, what happens to the charge of the atom? If atoms get charged, why might they bond?
Student B	#9: Student writes Mg_2O_2	3.5 (student has a small error in knowledge. Possibly confusing superscripts (oxidation number) with subscripts (# of atoms))	If Mg has a +2 charge and O has a -2 charge, how many of each atom would you need to get an overall charge of zero?
Student C	#9 and #10: Both errors occurred	2.5 (student has some understanding, but has inconsistent knowledge and little application).	Sign-up for a time to discuss this learning target. #9: If Mg has a +2 charge and O has a -2 charge, how many of each atom would you need to get an overall charge of zero? #10: When an atom gives or takes electrons, what happens to the charge of the atom? #10: If atoms get charged, why might they bond?

assessments. In my old system of grading, a typical student reaction to my efforts to provide feedback was to look at the grade and then promptly recycle the paper. At least they

FIGURE 7
Reassessment sign-up times on the whiteboard



recycled. I have found with standards-based grading, students read the feedback because the conversation isn't over with the assessment. Importantly, the learning doesn't end with the assessment. Furthermore, I have found the standards-based grading approach has vastly improved my ability to communicate student learning with students and parents. A few specific improvements I've experienced include:

- My instruction and assessments have improved because I have a better understanding of student thinking.
- The assessments support student responsibility because the students are responsible for coming in and improving their grades (and they do).
- Test anxiety has dramatically decreased because the learning isn't over with the test.
- As I have continued to develop standards-based grading in my classroom, I have also included more variety of assessments such as lab reports, verbal assessments, projects, and others.
- Assessments are put into the grade book by learning target. As a result, students and parents can pinpoint strengths and areas in need of improvement quickly and accurately.
- Research indicates providing feedback focused on what the student needs to improve and how to improve is critical for student growth (Kluger and DeNis, 1996; Clymer and Wiliam, 2006/2007). Students read the feedback because they actually use it to improve.

Helping students learn how to learn

When students come into our classrooms, they have pre-established beliefs about learning. These beliefs can interfere with research-based instructional and grading practices. The way students view learning and thinking can profoundly affect their ability to learn and think (Schommer, 1990; Jehng et. al., 1993; Chen & Pajares, 2009). Indeed, Kruse and Wilcox (2009) found students in a reforms-based classroom actively resisted the well-intended efforts of the teacher to mentally engage them.

While students often have inaccurate views of learning, how we teach and assess students can change not only what they learn, but how they view learning (Kruse et. al., 2010). Changing students' inaccurate beliefs of learning requires explicit instruction throughout the school year on what it means to learn. This includes explicitly asking students why we encourage them to discuss, debate, make decisions, and problem-solve in class instead of just telling them the answers.

One aspect of explicitly teaching students to learn how to learn is to change the way we grade and help students understand the rationale for the change. If students understand their grade reflects their level of understanding and they have the opportunity to improve their understanding, their views can begin to change. Students in the standards-based grading system "learn that smart is not something you are – it's something you become" (Clymer & Wiliam, 2006/2007). If we shift the way we grade, students may shift from "a performance orientation to their work, in which the goal is to get the highest grade, to a mastery orientation, in which the goal is understanding" (Dweck, 2000). Students learn that deep learning requires mental engagement, hard work, and time.

You may be wondering what students' reactions would be to a shift in grading. Once students understood the grading system (which took a few weeks), I heard almost all positive responses. I gave a survey to my students at the end of the school year in which their responses were anonymous and the results remained overwhelming positive (133 out of 135). The only real negative response was a few students wished the grading system included more numbers so if they had small gaps in understanding, they could still get "an A."

The following were some of the responses I received from students, in their own words:

- "You take it upon yourself to get a better grade."
- "You don't have to memorize stuff for like tests, you're just assessing what you learned."

- "It is easier to tell what you do and don't understand."
- "If we don't get it the first time, you can actually come back and learn it."
- "You can see which parts you're not getting right away."
- "It's way more specific and you get information [about your learning]."
- "You actually have to know it instead of just having a definition."
- "You get information on what you are doing wrong instead of just a percent."
- "We don't move on as a class unless we understand things."
- "We always get a reason why."
- "I like how you can come in and reassess."
- "We are problem-solving when we do things in class instead of just memorize this."
- "We actually have to know it."
- "It's a lot more asking questions and interacting instead of just learning things out of a book."

Conclusion

If we desire our students to become better learners, then we need to teach them how. Standards-based grading can be a useful tool in teaching students how to be accountable for their own knowledge and in the process help students understand what it means to truly learn. Changing the way we grade students is risky, but any change has some inherent risk. However, students will take responsibility if we encourage them and they will learn if we challenge them. I believe our students are worth the risk.

References

Chen, J.A. & Pajares, F.(2010). Implicit theories of ability of grade 6 science students: relation to epistemological beliefs and academic motivation and achievement in science. *Contemporary Educational Psychology*, 35(1), 75-87.

Clough, M.P. (2006). Why Inquiry? *Iowa Science Teachers Journal*, 33(2), 2.

Clymer, J. B., & Wiliam, D. (2006/2007). Improving the way we grade science. *Educational Leadership*, 64(4), 36-42.

Dweck, C. S. (2000). Self-theories: Their role in motivation, personality, and development. Philadelphia: Psychology Press.

Jehng, J., Johnson, S.D., & Anderson, A.D. (1993). Schooling and students' epistemological beliefs about learning. *Contemporary Educational Psychology*, 18, 23-35.

Kluger, A. N., & DeNisi. A. (1996). The effect of feedback interventions on performance: A historical review, a metaanalysis, and a preliminary feedback intervention theory. *Psychological Bulletin*, 119(2), 254-284.

Kruse, J.W., Wilcox, J. (2009). 9th Grade Student Resistance of Reform-based Instruction. Presented at the Association for Science Teacher Education Conference, Hartford, CT. January 8-10, 2009.

Kruse, J.W., Wilcox, J., Herman, B. (2010). Learning Dispositions: Explicit Instruction Concerning the Nature of Learning and Assessing Students' Views on Learning. Presented at the Association for Science Teacher Education Conference, Sacramento, CA. January 14-16, 2010.

Kruse, J.W. (2010). Grading Homework: A Waste of Time? Teaching as a Dynamic Activity Weblog. Retrieved June 21, 2011 from http://educatech.wordpress.com/2010/03/30/grading-homework-a-waste-of-time/

Penick, J.E. and Bonnstetter, R.J. (1993). Classroom Climate and Instruction: New Goals Demand New Approaches. *Journal of Science Education and Technology,* 2(2), 389-395.

Schommer, M. (1990). Effects of Beliefs About the Nature of Knowledge on Comprehension. *Journal of Educational Psychology*. 82(3), 498-504.

***Jesse Wilcox** is a graduate student at Iowa State University. He has taught science at the high school and college level and is also the recipient of the Excellence in Science Teaching Award from the Iowa Academy of Science. Contact Jesse at jwilcox.23@gmail.com with questions about this article or to receive additional tips about standards-based grading.*