



# Connecting Your K-12 Classroom to Next Generation Science Standards

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## Introduction: Next Generation Science Standards (NGSS) in K–12 classrooms

Over the last several years, the focus on STEM (Science, Technology, Engineering, and Math) education has caused a rapid evolution in how K–12 science is taught. STEM promotes a more systemic and integrated approach to teaching as well as more hands-on and minds-on ways of learning. Next Generation Science Standards provide a next-step for applying STEM approaches specifically to the study of science.

The NGSS are based on ideas introduced in the book *A Framework for K–12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* developed by the National Research Council (NRC). The Science Framework outlined in the book is designed to help students think and learn by using the same practices professional scientist use. It also identifies key ideas and practices that students must master by high school graduation to be successful in the field of science.

The successful incorporation of NGSS relies on teachers introducing and supporting these key ideas and practices. One way they can do it is by promoting a growth mindset within their classrooms. Nurturing the growth mindset will require teachers to conduct formative assessments throughout a given lesson to monitor and support student progress. By regularly conducting informal observations of nonverbal behavior, vocal cues and messages, teachers are better able to provide students the support and feedback they need to develop and maintain a growth mindset.

This paper provides research, tips, and strategies that administrators and teachers can use to:

- 1) understand the NGSS and growth mindset;
- 2) incorporate the NGSS into the science classroom; and
- 3) increase the successful use of growth mindset in the science classroom.

## Changing Mindsets to Increase Success

It might surprise many educators to know that the concept of the “growth mindset” is not new. As early as the 1900s, John Dewey, an American philosopher, psychologist, and educational reformer, stated that progressive education should value experience over simply learning facts. Specifically, he believed that when students begin with a problem or dilemma and work towards a solution, they will experience more meaningful learning. Today, it is still a commonly held belief that having the opportunity to wrestle with a dilemma may help students increase their retention and understanding of the key lesson presented in the classroom.

Dr. Carol Dweck is one of the world’s leading researchers in the field of motivation and the Lewis and Virginia Eaton Professor of Psychology at Stanford University. She has done extensive research on how to foster student success. She is also well known for acknowledging the existence and importance of the two learning mindsets. According to Dweck, some mindsets are fixed, meaning that learners believe their intelligence or talent is a fixed trait that cannot be

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improved through study or perseverance. Other learners have a growth mindset. In a growth mindset, learners believe that innate skills are a foundation, and dedication and hard work can help strengthen that foundation.

Often a student who believes that his or her skills are fixed and can't be improved upon may not work as hard to improve. It is clear to see why addressing student mindsets is critical for helping them succeed.

Dr. Dweck's research has proven that:

- Abilities are not carved in stone and can be developed over time;
- Intelligence and creativity can be improved and developed through deliberate instruction and practice;
- The brain has elasticity, so neurons can develop new connections through deliberate practice; and
- Growth mindset tends to encourage students to step out of their comfort zone and stretch themselves (Popova, 2014).

Dweck says, "The one thing that appears to set those who become geniuses or who make great creative contributions apart from their other talented peers is the deliberate practice they devote to their field." While it stands to reason that all students would understand the importance of study and/or practice, Dweck goes on to point out that "students with the growth mindset tend to orient more toward learning goals, and students with the fixed mindset tend to orient more toward validating their intelligence" (Dweck, 2008). Both types of students may believe they are "working hard," but only those with a growth mindset truly believe that they can push beyond their current limitations.

There are still many misconceptions about how mindsets affect learning. Here are three important things to know:

#### **It's possible to have both mindsets**

A person may believe he or she already has a growth mindset, or he/she may claim a fixed mindset. The reality is that most people exhibit a mindset that is both fixed and growth-oriented.

#### **Struggle is important**

Educators cannot foster a growth mindset simply by rewarding students for completing a task. Outcomes matter. Teachers should encourage students to push themselves and recognize their accomplishments when they use scientific practices in the right context and in the right way. "In the growth mindset, failure can be a painful experience. But it doesn't define you. It's a problem to be faced, dealt with, and learned from" (Dweck, 2008).

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### Knowing about mindsets can change them

Research shows that simply knowing about the existence of two mindsets can help students move toward the growth mindset. Teachers are in a good position to explain how the different mindsets work and why there are benefits to having a growth mindset.

Dweck recommends the following ways in which a growth mindset can be promoted:

- 1) Ensure that individuals understand that challenges, efforts, and mistakes are valued in education. Do not portray effortless work as being the only sign of success.
- 2) Give feedback on proper use of the process as well as receiving the “correct” outcome. Do not simply reward those that get the “right answer.”

These recommendations can be used for developing a growth mindset in teachers and students. The context of the discussion must simply be modified to incorporate the processes that are relevant to the population being addressed. The NGSS provides a structured framework to incorporate the growth mindset into the science classroom. However, it is important to ensure that teachers clearly understand the correlation between the two before implementation.

### Strengths of NGSS

**I**n 2012, the National Research Council (NRC) proposed that the K–12 Science Framework should include practices, crosscutting concepts, and core ideas. These dimensions are not meant to be taught in isolation, but rather integrated into every discipline.

#### Scientific Practices

The term “practices” emphasizes “that engaging in a scientific investigation requires not only skill but also knowledge that is specific to each practice” (Rybee, 2013). These practices include various tools and techniques and are not limited to scientific inquiry. This expands the teaching strategies that can be used in instruction.

Scientific practices describe:

- 1) The major practices that scientists employ as they investigate and build models and theories about the world
- 2) A key set of engineering practices that engineers use as they design and build systems (Rybee, 2013)

The practices defined by the NRC Science Framework should be taught to students in process form. If a step-by-step procedure is defined for each practice, then students can more easily apply the practice to any discipline. This will allow coordination of knowledge and skill.

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## Crosscutting Concepts

The crosscutting concepts defined by the NRC may be applied across all science domains.

“The crosscutting concepts are the themes or concepts that bridge the engineering, physical, life, and Earth/space sciences” (Pratt & Rybee, 2013).

The K-12 Science Framework illustrates how the crosscutting concepts may be used as scaffolding techniques for students as they progress through each grade level. These concepts will be used repeatedly to ensure understanding of, and connections between, the different disciplines.

## Core Ideas

The disciplinary core ideas are designed “to prepare students with sufficient core knowledge so that they can later acquire additional information on their own” (Pratt & Rybee, 2013).

Having core knowledge empowers students with an understanding of how to find and use appropriate resources, rather than waiting to be given the information in a direct instruction manner.

The disciplinary core ideas are grouped into four domains: 1) physical sciences; 2) life sciences; 3) Earth and space sciences; and 4) engineering, technology, and applications of science.

Teaching students these practices, crosscutting concepts, and core ideas helps them develop a more integrated view of science that closely emulates the day-to-day work of professional scientists. These dimensions also enable teachers across grade levels and disciplines to share ideas regarding instruction and assessment.

“The coordination of the three dimensions reinforces the importance of not separating the doing from the knowing” (Pratt & Rybee, 2013).

## NGSS in Action

**W**hen implementing the NGSS, there are skills that instructors must teach students to increase their potential for success in developing a growth mindset while solving problems. One of the first steps is to help students create a personal view of themselves that supports a growth mindset. Once a classroom culture that supports growth mindset has been created, struggle tasks should be developed to support that mindset.

Struggle tasks that support a growth mindset will include key elements:

- Proper timing and placement within the lesson
- Clear, specific learning goals
- Tasks that build on students’ prior knowledge and skills
- A safe environment in which students can explore and inquire
- Probing questions that require students to process information

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- Clearly defined and structured lessons that follow struggle tasks
  - Reflection activities for students at the end of each struggle task (Emeling, Hiebert, & Gallimore, 2015).

Rather than promoting the traditional models of teaching in which teachers direct the instruction, the NGSS promotes a “teacher as coach” model that supports inquiry. This change in instruction does not minimize the teacher’s role. In fact, this role will have an increased value as the teachers “help students engage appropriately, redirect and monitor them, and adjust supports along the way” (Vigeant, 2016).

Science practices become important to ensure that students are able to:

- Ask questions and define problems;
- Develop and use models;
- Plan and carry out investigations;
- Analyze and interpret data;
- Use mathematics and computational thinking;
- Construct explanations and design solutions;
- Engage in argument from evidence; and
- Obtain, evaluation, and communicate information (Pratt & Bybee, 2013, pp. 40-42).

Of course, the depth of the knowledge required is dependent upon the age and grade level of the students. However, NGSS prescribes an increasing depth of understanding of more complex ideas as the age and grade level increases.

When implementing NGSS, the evaluation of instruction should include formal assessments, and formative assessments become increasingly important. McMillan (2007) believes that the goal of formative assessment is the improvement of student motivation and learning. This is in alignment with encouraging a growth mindset in completing struggle tasks. Teachers must employ a circular, continuing process, which includes evaluations of student work and behavior, feedback to students, and corrective instruction.

Questioning must be targeted and specific. The purposes of questioning can range from involving students in the lesson to promoting students’ thinking and comprehension to assessing student progress (McMillan, 2007).

Effective questioning should:

- State questions clearly and succinctly;
- Match questions with learning targets;
- Involve the entire class;

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- Allow sufficient wait time for students to respond;
  - Give appropriate responses to student answers;
  - Extend initial answers;
  - Sequence questions appropriately; and
  - Ask questions of all students, not just those you know will answer correctly (McMillan, 2007).

Questions and informal observations will provide information and spur dialogue that enables the teacher to deliver proper feedback. Feedback is the transfer of information from the teacher to the student following an assessment. The feedback must be useful. Students need to know why their performance was graded as it was and what corrective procedures are needed to improve their performance (McMillan, 2007).

Teaching students how to complete a self-assessment can also be beneficial if the purpose is to involve students in the evaluation of their work so that they can receive immediate feedback. There should be an emphasis on progress and mastery of knowledge and understanding.

The biggest challenge is to get the students to do the self-assessment honestly. Honest assessments help students develop their abilities to form internal questions about their learning and performance, make decisions about what other learning is needed, and to be aware if projected learning plans are not making appropriate progress.

## Summary

**N** GSS standards necessitate a different approach to science instruction and assessment. The 2012 National Research Council (NRC) Science Framework can help guide instructors as they adjust their approaches. The NRC Framework promotes 1. teaching scientific practices with step-by-step procedures; 2. using crosscutting concepts as scaffolding to support students as they progress to new levels of understanding and new grade-levels; and 3. preparing students for more independent learning by teaching them core ideas.

Once teachers have integrated the Science Framework into their lessons, they can further encourage student learning by developing a growth mindset in their classrooms. Fostering a growth mindset in the K–12 science classroom can be rewarding, but it requires a cultural shift. Teachers must understand the research behind the mindset, so they can successfully incorporate the basic guidelines.

As teachers begin to use the NGSS standards, apply them via the NRC Science Framework and change their classroom cultures to align with a growth mindset, they will be able to foster a more engaging, inquiry-based classroom experience. Students who choose to become scientists will be prepared for the workplaces of the future, and those who do not pursue a science career will have gained learning skills that stay with them for a lifetime.

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