360Science™ Implementation Guide

THE NEXT GENERATION SCIENCE STANDARDS

The Next Generation Science Standards (NGSS) advocate an exploratory style of science education that would have students discover science's universally accepted truths, or disciplinary core ideas (DCIs), rather than read or hear about them. Students derive these facts during their efforts to understand phenomena, things observable in the natural world, by using seven Science and Engineering Practices (SEPs). Moreover, the NGSS imply that DCIs are best understood from interdisciplinary perspectives called Cross-cutting Concepts (CCCs). For example, a student will come to a deeper understanding of the Law of Conservation of Mass, a topic typically found in Chemistry courses, by relating it to photosynthesis, a topic typically found in Biology courses. Broad titles such as *High School Physical Sciences* therefore organize the NGSS. In essence, adoption of the NGSS by a teacher, school or district implies a belief that better long-term outcomes will result if students are trained to do science as it is done in an academic, government, or commercial research laboratory.

PEDAGOGICAL STANCE

We believe that when students do science the way it has been practiced since the advent of the Scientific Method, by figures like Marie Curie, Ernest Rutherford and countless others in research laboratories, they will better retain science's core facts and develop problem-solving skills increasingly valued in a complex world prone to automation of jobs. We also believe that such an approach to science education poses challenges, including time and resource constraints; unfamiliarity with this style of learning; and student groups of varying abilities and comfort levels. We therefore developed 360Storylines to be a practical solution for teachers, schools and districts wanting to adopt the NGSS. It is a tactile curriculum that lets teachers facilitate student-driven learning in reasonable time blocks, so that students figure out as much "content" as possible in a way that adheres to the vision of science education implied by the NGSS. We describe below how to use the elements of the curriculum to replicate for students the experience of being a scientist.

PROFESSIONAL DEVELOPMENT

One of the biggest hurdles to the implementation of a new teaching style is training, particularly where technology is involved. Please reach out to set up a one-on-one session with our implementation specialists and staff scientists.* We enjoy helping teachers implement this new, practical curriculum, and welcome opportunities to converse about all things science and science education, including the NGSS.

HOW TO USE THE COMPONENTS OF A 360STORYLINE

Synopsis

- A pdf document that provides: a storyline summary, descriptions of the three to eight experiments that comprise the storyline, a recommended sequence, performance expectations, and key concepts.
- Use to determine whether a particular storyline engages with targeted performance expectations, standards, or concepts.

Experiment Overview

- A pdf document that provides: a description of each of the four levels in an experiment, key concepts, a list of performance expectations; applicable DCIs, SEPs and CCCs; and learning outcomes.
- Use to determine whether a particular experiment engages with targeted performance expectations, standards, or concepts; and to judge which level of a lab is most appropriate for a student or cohort of students.

Driving Question Template

- A set of downloadable and editable MSWord documents that provides experiment-level driving questions related to investigative phenomena, storyline-level driving questions related to anchoring phenomena, and prompts to describe and refine a working model of the phenomena. The document set includes a student version with space for written or typed answers, and a teacher version with sample answers and reasoning.
- Use to guide students through a storyline. The driving question templates ask students to draw conclusions from observations and use their conclusive evidence to progressively render increasingly refined explanations of phenomena. It is important to note that the driving questions in these documents can be altered by teacher or student. They can also be shared in a public place such as in a Google Drive folder to allow for discourse both within and across student groups, and at the classroom level if desired.

Background Information

- A digital webpage accessible with an electronic device such as a Chromebook, iPad or PC that presents information students must know, or is helpful to know, in order to perform an experiment.
- Use to help students prepare for an experiment, especially when the material under study is complex and therefore may require a level of what some in the NGSS community refer to as "learning about."**

Experiment Templates

- A set of digital web pages that contain the traditional "content" associated with a laboratory experiment, including: Overview, Materials, Safety, Procedure, Summary, and Analyze and Interpret sections. The set includes four versions of a lab: a **short version** that can be done in a single period, a prescriptive, **guided version** that requires 1-2 periods, an **open version** that requires independent experimental design, and an **advanced** version that requires students "do science" in accordance with Achieve's *A Framework to Evaluate Cognitive Complexity in Science Assessments.*[***] The templates also include videos, writable data tables and writable answer boxes, in which procedures, data and answers may be recorded and submitted digitally. Every section of an experiment template is completely editable - the platform allows for this by rendering modifiable html code into an easy-to-use interface.
- Use to help students apply SEPs to discover targeted DCIs. Students make observations and draw conclusions that they use to understand investigative and anchoring phenomena laid out in *Driving Question Templates*. For example, in an **open** version students must decide what data to collect to answer experiment-level driving questions, and how to do so in a controlled fashion. Students not accustomed to an exploratory style of learning can engage in a **guided** version of the lab. Also, you can modify any section of a lab, including the procedure, to suit a target learning outcome or student comfort level. This ability to provide a personal experience for each student allows for practical implementation of the NGSS vision of science education, because some students struggle with independent decision-making, and require a slow transition that can begin with prescriptive lab experiences.

Videos

- A set of videos that helps students understand DCIs and connect them to phenomena, and understand unfamiliar equipment and lab techniques.
- Use to facilitate understanding of DCIs and their relationships to phenomena, and unfamiliar lab techniques. Students can view videos anytime on any internet-capable device. For example, students might watch videos before an experiment to gain a higher degree of comfort prior to participation, or during lab as they encounter difficulty. We believe that multimedia is a powerful complement to hands-on science. This idea is discussed in several very interesting manuscripts in the science education literature.[****]

Assessments

- Opportunities for students to demonstrate their understanding of DCIs and CCCs, and proficiency in applying SEPs. These include gradable procedures, gradable data tables, gradable analyze and interpret questions, and responses recorded in *Driving Questions Templates.*
- Prior to implementation of any NGSS curriculum, we recommend reading Achieve's *A Framework to Evaluate Cognitive Complexity in Science Assessments.*[***] The framework describes a qualitative scale for assessing single items and multi-component tasks, that ranges from *Scripted* to *Doing Science*. A student performs at the "*Doing Science"* level if the student can engage in a task *"...with limited to no scaffolding across all three dimensions; [and] decide how to engage and execute within the task."* A 360Storyline allows you to make and record this type of judgement. For example, you can assign a four-point scale to a student-written procedure wherein "4" represents "*Doing Science.*" The empirical score can be combined with feedback like: "The student was able to design an experiment to answer a relevant question by identifying appropriate independent, control and dependent variables; and was able to set up an appropriate apparatus to enable data collection. The student drew reasonable conclusions from her data and was able to connect them to the phenomenon under study."

Simulations

- Virtual reality experiences that help students connect the sub-microscopic to the macroscopic. For example, a student can observe a glass of water but it is impossible to see the hydrogen-bonding interactions present between the molecules, that are in part responsible for water's physical properties.
- Use to help students connect the submicroscopic world to the macroscopic world, to better understand DCIs and connect them to phenomena.

Teacher Notes

- A set of four downloadable and editable MSWord documents that provides sample answers to assessments, sample data, sample procedures, preparation and safety information, and helpful tips and suggestions.
- Use to assess student performance against model answers, data and responses. You can print hard copies of the lab procedures using these documents, if desired.

Supplies

- The necessary consumables and some durable equipment needed to carry out an experiment. Lists of the materials associated with each 360Storlyine are available as downloadable documents on www.flinnsci.com and www.flinn 360science.com. We believe that most of the NGSS DCIs require manipulation of physical materials, as opposed to theoretical study only, to truly understand. This idea is discussed in a fascinating study performed at the University of Chicago that describes a positive, causal relationship between hands-on science and learning outcomes.*****

* Please get in touch by emailing Chrystie Kovalev at ckovalev@flinnsci.com.
** The term "learning about" is often used to describe the "traditional" means by which students are exposed to science content, wherein teachers tell them the facts or they read about them. This is in contrast to the style espoused by the NGSS, often called "figuring out."
*** Accessed at https://www.achieve.org/cognitive-complexity-science; December 2019.
**** 1. Stieff, M; Werner, S. M.; Fink, B.; Meador, D. Online Prelaboratory Videos Improve Student Performance in the General Chemistry Laboratory. *J. Chem. Educ.* 2018, *95*, 1260-1266.
2. Cresswell, S. L.; Loughlin, W. A.; Coster, M. J.; Green, D. M. Development and Production of Interactive Videos for Teaching Chemical Techniques during Laboratory Sessions. *J. Chem. Educ.* 2019, *96(5)*, 1033-1036.
***** Kontra, C.; Lyons, D. J.; Fischer, S. M.; Beilock, S. L. Physical Experience Enhances Science Learning. *Psych. Science*. 2015, *26(5)*, 737-749.