Playbook for Three Dimensional Science Instruction

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Rationale

The teaching and learning of science is currently undergoing a radical transformation in the United States. The publication of the Framework for K-12 Science Education and the release of the Next Generation Science Standards (NGSS) has encouraged science educators to reevaluate the way in which they deliver science instruction. A driving force in the shift has been the de-emphasis of science being a body of facts that must be learned. Instead students are being asked to think and behave like scientists and engineers in figuring out how and why things work. This change necessitates that teachers empower students to take charge of their own learning. These strategies offer a sample of ways in which educators can embed the three dimensions of NGSS into their instruction.

Claim + Evidence + Reasoning = Constructing Explanations

What is it?

When students are asked to write conclusions for experiments they often fall short of constructing a complete explanation. The claim-evidence-reasoning (CER) model provides a framework for students to construct explanations that begin with a claim as an answer to the question being investigated. It then asks for evidence or data to support the claim and ends with scientific reasoning that justifies how and why the evidence supports the claim using scientific ideas. Students can use the CER model in a variety of contexts when conducting first hand investigations or even reporting out on data presented in graphs.

How does it support NGSS instruction?

Claim – Evidence – Reasoning is an excellent strategy to ensure that students are supporting their findings. It can be used with the following SEPs…

- Developing & Using Models
- Constructing Explanations & Designing Solutions
- Engaging in Argument from Evidence
- Obtaining, Evaluating, and Communicating Information

Where can I learn more?

- *Claims, Evidence, and Reasoning* journal article ins NSTA's Science and Children, April/May 2011
- CER - Claim Evidence Reasoning – Video from Paul Anderson at Bozeman Science
- Inquiry and Scientific Explanations: Helping Students Use Evidence and Reasoning chapter from *Science Inquiry in the Secondary Setting*, NSTA 2007
- CER Template and Rubric from Kevin Anderson while at CESA 2
- Claim-Evidence-Reasoning in the Context of K-12 Science and Engineering blog by Francis Vigeant from KnowAtom

Driving Question Board

What is it?

Driving question boards provide an opportunity for students to feel in control of their own learning. The driving question gets at the heart of what students should learn within a unit of instruction. Students begin to add other questions that support the original driving question. These questions then get organized to plan the necessary investigations to figure out answers to the questions. When used well students bring in their own evidence from life experiences and conduct investigations to generate answers for other questions. In the end students will put together all of the pieces to solve the overall question for the unit.

How does it support NGSS instruction?

Driving question boards can be used in all units of instruction with all of the DCIs, CCCs. However, they strongly support the following SEPs…

- Asking Questions & Defining Problems
- Developing & Using Models
- Planning & Carrying Out Investigations
- Obtaining, Evaluating, & Communicating Information

Where can I learn more?

- Enhancing Science Kits With the Driving Question Board article from NSTA's Science & Children, 2012
- What is the Driving Question Board in IQWST? Video from ActivateLearning
- How to Write Effective Driving Questions for Project-Based Learning article by Andrew Miller on EduTopia
- Driving Questions archived webinar from the Buck Institute for Education
- NGSS Storylines: How to Construct Coherent Instructional Sequences Driven by Phenomena & Motivated by Student Questions presentation by Brian Reiser at Illinois Science Teachers Association, 2015

Engineering Design Process

What is it?

With the inclusion of engineering in the NGSS it is important that all science educators become versed in the engineering design process. While there are many variations of this process the premise is simple. Students begin by defining problems that can be solved. They then design solutions to those problems. Finally they test and revise those solutions. As with all things there is a progression of complexity as students develop. Engineering with the NGSS should be embedded with the science content, as student will rely on these concepts in their designs.

How does it support NGSS instruction?

The engineering design process is inherent in the Engineering, Technology and the Application of Science (ETS) DCIs. It also can be used with all of the SEP's

Where can I learn more?

- Appendix I – Engineering Design in the NGSS from nextgenscience.org
- New Science Standards Emphasize the Engineering Design Process article by Amy Cowen from ScienceBuddies
- Engineering in the Classroom from the NASA Jet Propulsion Laboratory
- Engineering in an NGSS Classroom video from the Teaching Channel
- Core Ideas of Engineering & Technology article from NSTA's January 2012 journals

Formative Assessment Probes

What is it?

Formative assessment strategies should be used frequently in any classroom to gage student understanding and adjust the instructional trajectory. Assessment probes are simple tasks that present student with a scenario where they are prompted to make a decision and then justify why they did so. Page Keeley has published many formative assessment probes for science and math. However, the format is simple enough to design you own.

How does it support NGSS instruction?

It is possible to assess all DCIs, CCCs, and SEPs using formative assessment probes.

Where can I learn more?

- UncoveringStudentIdeas.org website by Formative Assessment Probe Author Page Keeley
- Formative Assessment Probes journal article from NSTA's Science & Children
- Keeley Probes as a Tool for Uncovering Student Ideas master's thesis by Kalin Tobler at Portland State University

Modeling

What is it?

Models are representations of real objects or systems that are often not readily understood due to scale or complexity. True scientific models go beyond the traditional 3D representations used in in classrooms. They are often referred to as conceptual models or explanatory models because they are used as a means of explaining understanding. While they include components of systems and the relationships that exist between them, they are often incomplete and inaccurate. Part of the scientific process involves the testing of models against reality and refining them to provide more thorough explanations. Modeling in the classroom can involve whiteboards, diagrams, physical replicas, mathematical formulas, and computer simulations.

How does it support NGSS instruction?

While modeling is one of the SEPs, it is also strongly connected to…

- Asking Questions & Defining Problems
- Developing & Using Models
- Analyzing & Interpreting Data
- Using Mathematics & Computational Thinking
- Constructing Explanations & Designing Solutions
- Engaging in Argument from Evidence
- Obtaining, Evaluating, and Communicating Information

Where can I learn more?

- What does constructing and revising models look like in the science classroom? journal article from NSTA's Science and Children
- *Explanatory Models: A Highly Effective Way to Support Science Learning* blog by Alissa Berg from Teaching Channel
- Models and Modeling: An Introduction from Ambitious Science Teaching
- Developing & Using Models video from Paul Anderson from Bozeman Science
- Making Thinking Visible: Modeling and Representation chapter from Ready, Set, SCIENCE!: Putting Research to Work in K-8 Science Classrooms from National Academies Press

Phenomenon Based Instruction

What is it?

Phenomena are observable events that present instructors with an opportunity to catch student interest and motivate them to want to investigate it and explain why it occurs. Instructors can find phenomena connected to all science content. Engaging students with firsthand experiences with phenomena is preferred, while some can only be observed through videos. Anchoring phenomena can be the basis of an entire unit and often require multiple investigations to derive full understanding. Lesson based phenomenon are generally smaller in scope and can be understood within a smaller time frame.

How does it support NGSS instruction?

The use of phenomenon can apply to all DCIs and CCCs. However, it is especially useful when using the following SEPs…

- Asking Questions & Defining Problems
- Developing & Using Models
- Constructing Explanations & Designing Solutions
- Engaging in Argument from Evidence

Where can I learn more?

- Using NGSS Phenomena To Engage Students article and archived webinar from Rubicon
- Using Phenomena video from the Teaching Channel
- Phenomena for NGSS website by T.J. McKenna
- Using Phenomena in NGSS-Designed Lessons and Units Q & A from nextgenscience.org
- 6 Steps to Coming Up With an Engaging Phenomenon to Anchor Your Next NGSS Unit blog by Alissa Berg from Teaching Channel

Talk Moves – Productive Discussion Techniques

What is it?

Students need opportunities to share their thinking in a safe environment that will offer opportunities for reflection, justification, and refinement. Educators can create opportunities and a culture that supports productive discussions among students in small and large groups. The Talk Moves are sentence stems and prompts that encourage students to communicate with clarity and purpose. They foster discussions that help students to understand each other's thinking and clarify their own arguments.

How does it support NGSS instruction?

Talk moves can be a valuable tool used with many of the SEPs including…

- Developing & Using Models
- Planning & Carrying Out Investigations
- Constructing Explanations & Designing Solutions
- Engaging in Argument from Evidence
- Obtaining, Evaluating, and Communicating Information

Where can I learn more?

- The Inquiry Project from TERC is a grade 3-5 physical science curriculum that developed and utilized Talk Science Primer
- Talking the Talk: Tips for Engaging Your Students in Scientific Discourse blog post from the Teaching Channel
- Participation in Scientific Practices and Discourse chapter 7 from *Taking Science to School: Learning and Teaching Science in Grades K-8*
- How can teachers guide classroom conversations to support students' science learning? Practice Brief #48 from Stem Teaching Tools

Science Notebooks

What is it?

Science notebooks provide opportunities for students to make their learning and thinking visible. As students document their science learning they strengthen their language and organizational skills. Science notebooks can contain a wide variety of entries that will be used daily by students including, vocabulary, diagrams, class notes, documentation of investigations including data tables and conclusions. Interactive science notebooks offer the opportunity for students to document their learning and make sense of their understanding

How does it support NGSS instruction?

Science notebooking allows student to engage in all of the SEPs, CCCs and DCIs

Where can I learn more?

- *Science Interactive Notebooks in the Classroom* NSTA article by Jocelyn Young found on NSTA WebNews Digest
- Using Interactive Notebooks for Inquiry-Based Science NSTA article by Robert Chesbro found on NSTA WebNews Digest
- Science Notebook Corner website by the California Academy of Sciences
- STEM Notebooks website from Washington State LASER

Summary Table

What is it?

Summary tables are a public record of the learning experiences carried out by the class in an attempt to answer a main focus question for the unit. Each activity/entry should bring students one step closer to understanding the answer. Columns for summary tables should include titles of the activities, observations/SEP/CCC connections, and explanations. Students can keep a copy of the summary table in their science notebooks.

How does it support NGSS instruction?

Summary tables support all DCIs, SEPs & CCCs as students reflect on their learning.

Where can I learn more?

- Using Summary Charts to Press for Evidence and Promote Coherent Science Instruction blog by Alissa Berg from Teaching Channel

  Summary Tables page on Olympic Education Services website.

- Step 5 in The Modeling Toolkit: Making Student Thinking Visible with Public Representations journal article in NSTA's Science Teacher