Inquiry-based Teaching and Learning

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Science is built up of facts, as a house is with stones.
But a collection of facts is no more a science than a heap of stones is a house.

~ Henri Poincare

What does the present body of research say about effective science teaching? Below are instructional methods mentioned in the literature and while it's not true that simply using these methods will make you a highly effective educator, it is true that highly effective educators are using these methods. Better still, all educators can improve their use of these methods over time with effort.

Constructivism is a philosophy about learning that proposes that learners should build their own understanding of new ideas or skills. When newfound knowledge doesn't fit with a learners current schema of the world, he or she must break down and reconstruct that knowledge. Constructivism transforms today's classrooms into a knowledge-construction site where information is absorbed and knowledge is built upon prior knowledge. It also changes the traditional role of the teacher from "sage on the stage" to "guide on the side" to support science experiences that mirror the enterprise of doing real science as closely as possible.

Constructivism is built predominately on the work of Jean Piaget (1896-1980) and Lev Vygotsky (1896-1934). Both Piaget and Vygotsky appreciated the essence of building constructs and internalizing the knowledge given, rather than accepting the information as presented through rote-memory. Constructivist learning environments promote the learner to gather, filter, analyze, and reflect on the information provided, and to comment on this knowledge so that it will result in individualized comprehension and private learning.

Inquiry is an educational or learning process that is based on constructivism noted above. It has been described as an approach to teaching that involves a process of exploring the natural or material world, asking questions, and making discoveries in the search of new understandings. Once again the teacher is fundamentally a facilitator and a guide in inquiry-based learning and instruction.

Subsets of inquiry instruction have been noted in instructional publications over the past decade. They include:

- **Open or Full Inquiry:** students lead the scientific question, design, scientific investigations or experiment, and communicate the results;
- **Guided Inquiry:** the teacher selects the overarching question to investigate and then students engage in methods to scientifically determine the answer;
- **Structured Inquiry:** Students follow specific teacher-lead directions.

Science and Engineering Practices are what the Framework for K-12 Science Education and the Next Generation Science Standards refer to as an extension of inquiry.

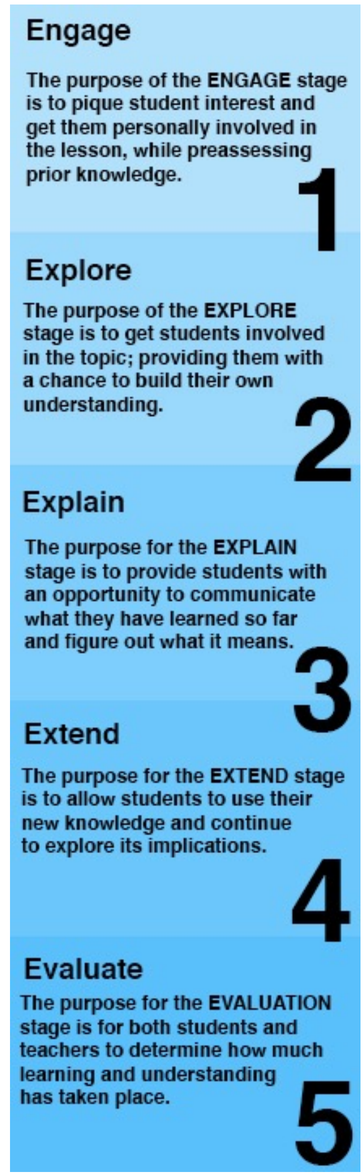
> *Science practice involves doing something and learning something in such a way that the doing and learning cannot really be separated. Thus, "practice" . . . encompasses several of the different dictionary definitions of the term. It refers to doing something repeatedly in order to become proficient (as in practicing the trumpet). It refers to learning something so thoroughly that it becomes second nature (as in practicing thrift). And it refers to using one's knowledge to meet an objective (as in practicing law or practicing teaching). (Michaels, Shouse, and Schweingruber 2008, p. 34)*

Rodger Bybee, Executive Director Emeritus of Biological Sciences Curriculum Study (BSCS), wrote an article entitled, *Scientific and Engineering Practices in K -12 Classrooms* in 2011 for NSTA's journals. He notes that scientific inquiry is one form of scientific practice. So, the perspective presented in the framework is not one of replacing inquiry; rather, it is one of expanding and enriching the teaching and learning of science. The six practices are listed below as an integral part of teaching science as outlined in the **Next Generation Science Standards.**

- Asking questions and defining problems
- Developing and using models
- Planning and carrying out investigations
- Analyzing and interpreting data
- Using mathematics and computational thinking
- Constructing explanations and designing solutions

A Few Instructional Models for Teaching Science

The 5E Learning Cycle Instructional Model is credited to Rodger Bybee with the Biological Science Curriculum Study (BSCS). It grew and expanded the work of many whose work preceded him (Atkins, Karpus, Their, etc.). It originated as a 3-phase model (Exploration, Concept Development, and Application) and evolved into what it is today. "Engagement" was added as the fifth and final E with the recent emphasis on constructivism and assessing prior knowledge. In total, the five steps include: engagement, exploration, explanation, elaboration, and evaluation. Each is summarized in the accompanied box with a few templates here(5E NGSS Template 2 and NGSS 5E lesson plan template 2) for curriculum planning purposes .



Project-based Learning is a teaching method well-suited to science and builds engagement through adding relevancy. Students investigate and respond to a complex question, problem, or challenge over an extended period of time. The method grew out of the work of John Dewey (1859-1952) and the Buck Institute of Education. Characteristics of these methods usually include being student centered as well as including the following:

- A driving question based on a strong "need to know"
- Significant content
- 21st Century competencies
- Voice and choice
- Critique and revision
- Public communication beyond peers

If you haven't done so, dive in and give the science and engineering practices of NGSS and inquiry-based teaching a try!