"Best Practices" of Science Teaching

Student Performance Objectives:

- The teacher candidate will accurately list and describe each of the authentic best practices of science teaching.
- The teacher candidate will accurately describe each of the so called "best" (desirable) practices and provide an example of each.
- The teacher candidate will distinguished between best practice so called and authentic best practice.
- The teacher candidate will explain briefly the findings of the Illinois Best Practices Framework.

THE AUTHENTIC BEST PRACTICES OF SCIENCE TEACHING: The following four pedagogical practices can be said to be truly best practice according to *How Students Learn: History, Mathematics, and Science in the Classroom* (National Research Council, 2005). The empirical evidence that supports their use is substantial.

- ***Engaging Resilient Preconceptions*** (addressing students' initial understanding and preconceptions about topics)

Students do not come into the classroom as "tabula rasa." They are not blank sheets to be written on. Each student comes into the classroom with ideas that often limit what a student can learn. It is critical that student preconceptions be identified, confronted, and resolved.

- ***Organizing Knowledge around Core Concepts*** (providing a foundation of factual knowledge and conceptual understanding)

Organizing information can be a powerful way to increase understanding and retention. For instance, recognizing a pattern can be a powerful adjunct to retrieval. For instance, if you were to ask a student to memorize the following list of number, (s)he would have a difficult time unless the underlining pattern were made visible: 13, 7, 19, 10, 4, 1, 25, 16, 22, 28. If the pattern is made clear by essentially rearranging the information, a rule can readily by established that makes remembering the sequence very easy: 1, 4, 7, 10, 13, 16, 19, 22, 25, 28. The rule is "Starting with one, it's every third number until 28 is reached." The core concepts of physics are such things as conservation of energy, momentum, charge, matter, etc. These are some of the "big ideas" identified in the National Science Education Standards. Similarly, it would pay dividends for students to received direct instruction to come to know how the "problem-solving process" is conducted rather than through "learning by example."

- ***Supporting Metacognition and Student Self-Regulation*** (teaching strategies that will help students take control of their learning).

Students need to be made fully aware of what they know and what they don't know. This can often be accomplished by requiring students to summarize what they have learned. Alternatively, the use of a "sample test" or a "pre-test" can be used to help students become more aware of what they know and don't know.

Socratic dialogues can be used to the same end. There are many heuristics that can be used to help students self-assess and then self-regulate.

- ***Cooperative Learning*** (allowing students to learn together)

Cooperative learning should not to be confused with group learning - there are huge differences. Cooperative learning calls for PIG'S FACE: positive interdependence; individual accountability, group processing, social skills, and face-to-face interaction.

THE SO-CALLED BEST PRACTICES OF SCIENCE TEACHING: The following are "best practices" so called; in reality they should be deemed *desirable practices*; the practices are commonly promoted on the basis of ideology rather than on the findings of empirical research. Even though there may only be anecdotal evidence (craft wisdom) to support the use of these practices, they often are closely associated with student success.Some of the major "best" (desirable) practices for science teaching are the following:

- Establishing and maintaining classroom environments that are:
  - learner centered -- identifying, confronting, and resolving preconceptions, and beginning instruction with what students know.
  - knowledge centered -- focus on how something is know as much as what is known, and provide examples of what mastery looks like.
  - assessment centered -- make frequent attempts to make students' thinking and learning visible as a guide for further instruction.
  - community centered -- encourages a culture of questioning, including a bit of risk taking and respect for others
- Using an empirical approach
- Regularly employ active learning strategies
- Employ inquiry labs
- Talk about the nature of science
- Provide meaningful, engaged learning for all students.
- Provide an active approach to learning that includes a strong emphasis on student interaction with phenomena.
- Clear and explicit linkage between representations and phenomena represented.
- Engage students in challenging, authentic, interdisciplinary tasks.
- Provide opportunities for students to observe, explore, and test hypotheses.
- Eliminate discipline boundaries when natural, logical, and appropriate.
- Encourage the students' imagination, logic, and open-mindedness.
- Incorporate the content and processes of science giving due regard to science teaching standards.
- Give due regard to affective as well as cognitive domain.
- Link scientific concepts and processes with prior learning in science and other disciplines.
- Using a constructivist approach.
- Depth and breadth of coverage are reasonably balanced.
- Goals of tasks are conceptual and conceptual means are required to accomplish them.
- Assigning manageable tasks (respecting the Zone of Proximal Development)
- Setting high expectations
- Engage all learners in meaningful scientific tasks involving high-order thinking skills.
- Providing and receiving feedback
- Accommodating student learning styles
- Teaching in a way that is consistent with student development

- Including real-world applications in the learning process
- Using individual and group motivation
- Moving from concrete to abstract
- Requiring practice of learned skills
- Employing learning cycles - observation, generalization, verification, application
- Making use of multiple intelligences
- Establishing conducive learning environments
- Encouraging student evaluation of alternative hypotheses
- Addressing conceptual goals and means
- Eliciting and addressing misconceptions
- Promoting critical thinking
- Creating, sharing, and using scoring rubrics
- Aligning objectives, instruction, and assessment
- Focusing on depth in addition to breadth of coverage
- Placing strong emphasis on interaction with phenomena
- Making clear and explicit linkage of representations to phenomena
- Using multiple representations of physical phenomena
- Employing Socratic dialogues

Many of the above "so-called best practices" are summarized and examples are given in the chapter "Guided inquiry in the science classroom" by Minstrell, J. & Kraus, P. found in *How Students Learn: History, Mathematics, and Science in the Classroom*. (M. Suzanne Donovan and John D. Bransford, Editors) Washington, DC: National Research Council (2005). Other best practices are to be found in Robert Marzano's *Classroom Instruction that Works*.

According to the ***Illinois Best Practices Framework***, the following are some additional best practices associated with school success as measured with IGAP and PSAE tests statewide. Visit the website to find an interactive version of the table below with links providing detailed information about the various practices.

ORGANIZING THEMES	DISTRICT PRACTICES	SCHOOL PRACTICES	CLASSROOM PRACTICES
CURRICULUM & ACADEMIC GOALS	Align the district curriculum to state standards by grade level and subject area	Set targeted academic goals based on analysis of student achievement data	Ensure district standards, benchmarks and specific academic goals drive instruction
STAFF SELECTION, LEADERSHIP, & CAPACITY BUILDING	Make teaching and learning the primary focus for school administrators	Select highly qualified teachers and provide professional development based on students' needs	Collaborate focusing on curricular and instructional issues
INSTRUCTIONAL PROGRAMS, PRACTICES, & ARRANGEMENTS	Provide programs that are aligned to state standards and have a solid research base	Tailor programs, practices and arrangements to address the learning needs of the student population	Use assessment data to inform instructional practices

MONITORING: COMPLIATION, ANALYSIS, & USE OF DATA	Analyze national, state and district assessment data to monitor schools and identify achievement gaps	Monitor teacher and student performance using assessment data and classroom observations	Use various assessment methods to continuously monitor student learning
RECOGNITION, INTERVENTION, & ADJUSTMENTS	Support schools by communicating successes and providing additional staff and programs for interventions	Intervene based on identified students' needs. Recognize academic and behavioral achievement	Identify in a timely manner students who need interventions to reach academic and behavioral goals