- ask probing questions, promote discussion, and focus on making meaning and applications of learning to technology and society
- use classroom assessments to gather evidence of student achievement and to inform instruction (AAAS, 1993; Hammerman & Musial, 1995; Jarrett, 1997; NRC, 1996)

OVERVIEW OF CHAPTERS

Part I: Creating a Vision for Successful Science

The first two chapters create a vision for understanding science standards and the goals of science education. These chapters provide a rationale for classroom practice that is based on the work that scientists do and the ways scientists think and act and create an awareness of high quality teaching that is applied throughout the book.

Understanding Standards

The work of science professionals defines the nature of science and describes the role of inquiry-based science in uncovering and discovering the mysteries of the universe. The concepts and principles of the science disciplines inform national and state standards that come under the headings of the Nature of Science, as well as Life Science, Earth/Space Science, and Physical Science. The standards also address the skills and dispositions for P–12 science and identify important goals for the development of the scientifically literate citizen.

High Quality Science Education

Well-designed instructional materials can be used to inform and guide the delivery of high quality instruction in the classroom. A research-based set of indicators of high quality curriculum and instruction are identified for use in the design or modification of standards-based units and lessons to enhance student achievement.

Part II: Giant Steps to High Quality Teaching

Pedagogical Content Knowledge

Throughout Chapters 3–8 a strong case is made for the importance of content knowledge as well as pedagogical content knowledge for effective teaching and learning. Pedagogical content knowledge includes, in the words of Lee Shulman (1986):

> the most useful forms of (content) representation . . . the most powerful analogies, illustrations, examples, explanations, and demonstrations—

> in a word, the ways of representing and formulating the subject that makes it comprehensible for others. (Gess-Newsome & Lederman, 1999, p. 4)

Pedagogical content knowledge is operationally defined in this book through the identification of indicators of high quality science teaching and their application to a process for the development (or modification) of instructional materials to inform and guide instruction.

Creating Blueprints for High Quality Teaching

Indicators of high quality and the steps in the unit development process are aligned in Chapters 3 through 8. These chapters describe a process for creating "blueprints" to guide the delivery of high quality classroom instruction. The indicators of high quality serve as beacons that guide the process.

Table P.1 Eight Steps to High Quality Teaching

Chapter	Indicators of High Quality Teaching	Steps for Developing High Quality Units and Lessons
3	**Steps One–Three** Address clear and appropriate learning goals Build concepts and principles Develops skills and practises dispositions valued by the scientific community	**Steps One–Three** 1. Select a topic or theme from the state or local framework for science education for your year level. Research and review content information about the topic. 2. Select a set of key concepts and principles appropriate for the year level around which the unit will be developed. • Design one or more graphic organizers to show relationships between concepts or concept categories for the unit. 3. Consider process skills of science, critical and creative thinking skills, and dispositions to include and emphasize.
4	**Step Four** Accommodates diversity through meaningful contexts	**Step Four** Create a context for meaningful learning. • Consider various types of contexts for the development of high quality instruction. • A sample unit in a cultural context is included.

Table P.1 (Continued)

Chapter	Indicators of High Quality Teaching	Steps for Developing High Quality Units and Lessons
5	**Step Five** Includes varied methods that engage and challenge students intellectually and address prior learning, misconceptions, and new learning Embeds strategies that allow students to develop new or modified thinking frames with links to their own lives, technology, and issues relevant to their community, state, nation, and world	**Step Five** Research learning activities and experiences. Modify existing activities or design new activities. • Use a consistent format for crafting each instructional activity and experience. • Include multiple and varied methods and strategies for meeting the needs of learners. • Consider activities and experiences for relearning and for extended learning.
6	**Step Six** Develops thinking and problem-solving skills by using questioning and other strategies for students to make sense of what they are learning	**Step Six** Include a variety of ways for students to frame thought, link new learning to prior learning, and make connections to their lives, technology, and society. • Develop a student notebook that reflects what students will design, do, record, write, research, and so forth throughout the unit. • Frame thought and show understanding and meaning through visuals, performances, products, and so forth.
7	**Step Seven** Incorporates a well-designed assessment system to monitor and guide the learning process and to provide frequent feedback to students about their learning	**Step Seven** Design a rich assortment of formative assessments. • Establish rubrics to enable students to self-assess. • Use assessment data to assess effectiveness of unit.
8	**Step Eight** Utilizes equipment, materials, and resources for enhancing learning and providing a challenging learning environment	**Step Eight** Consider resources, equipment, and materials that will be needed for effective instruction. Consider management strategies and safety issues.

The enriched environment permits and even encourages "risk-taking," which is necessary for knowledge acquisition and the development of higher order thinking and problem solving to occur.

Thought and Discussion

1. Consider the interest/awareness of purpose chart, strategies related to the multiple intelligences, conditions related to downshifting, conditions of enriched environments, relationships between emotions and learning, and factors related to the degree of brain stimulation.
2. Discuss some implications of these messages for enriching the context, conditions, and approaches to instruction in the classroom and increasing the possibility that students will operate in a state of "flow."

CONTEXT AND CULTURAL DIVERSITY

The question of "what do we know about education and diversity, and how do we know it" was the focus of a four-year study www.newhorizons.org/strategies/multicultural/ banks.htm (Banks et al., 2001) .

The findings were synthesized into a set of essential principles that describe ways in which educational policy and practice related to diversity can be improved. They support the notion that democratic societies depend on a thoughtful citizenry that believes in democratic ideals and is willing to participate in the civic life of the nation. Further, they contend that public schools are the key to maintaining a free and democratic society.

> The panel found that textbooks and teacher-designed lessons often present historical events, concepts, and issues from a single point of view (generally, the victor) and, often, do not help students understand how events and concepts relate to different groups of people who were involved in them.
>
> One of their recommendations: "Teaching students the different, and often conflicting, meanings of concepts and issues for the diverse groups that make up the [...] population will help them to better understand the complex factors that contributed to the birth, growth, and development of the nation." (Banks et al., 2001, p. 198)

Dr. Gerry Madrazo (1998) supports the notion that a multicultural curriculum fosters respect for diversity. "A multicultural curriculum results in respect for diversity flowing from knowledge. With that respect will come the ability of people to live and work together in a diverse society" (p. 22).

SCIENCE IN MULTICULTURAL CONTEXTS

Consideration might be given to the ways that different cultures view the concepts or principles of science.

One approach is to compare and contrast cultural perspectives with contemporary views. For example, when studying the natural world, elementary students might consider such questions as:

- How did Indigenous Australians (or other cultures) explain the Sun and the heavenly bodies?
- What animals are considered "sacred" in some cultures and why?
- Why are some animals feared in some cultures?
- What plants were historically used as food or medicine by different cultures?
- What significance do certain minerals and/or gems have in different cultures?
- Why were early civilizations built with certain types of building materials?

Stories and legends offer a wonderful way to study history and to celebrate diversity in the classroom. Stories and legends often are handed down from generation to generation to explain events in nature. They give insights into the ways that early civilizations interpreted natural phenomena long before there were materials, mathematical formulas, and records to explain them. Early people made inferences and invented stories to explain the wonders they observed.

A Standards-Based Science Unit in a Multicultural Context

The unit described here provides a model for how the eight steps for the development of high quality instructional materials can be applied to a theme in a cultural context.

Steps One–Three: Topic/Theme—Interdependence of Plants and Animals

Standards and key concepts and processes: Standards-based concepts may be addressed through the study of an ecosystem or variety of ecosystems including those related to:

- the roles of light, range of temperatures, and soil composition in an ecosystem's capacity to support life
- the structure and functions of organisms within the population of an ecosystem: producers, consumers, decomposers; the variety and numbers of organisms an ecosystem can support
- the Sun as the source of energy for an ecosystem; the flow of energy and interactions of organisms within a system (food chain/food web)

In addition, students will use process skills of science to investigate concepts and solve problems and to develop thinking skills and practise valued dispositions.