Introduction

"The Battle Continues Over Stem Cell Research"

"More of the Mysteries of Saturn Discovered"

"Journal Reports Advancements in Technology and Medicine"

"Scientists Detail and Make Predictions About Climate Changes"

These are just a few of the many headlines and topics that flood the media and point to current and future issues that children will face as citizens in a global community. Preparing students to understand and adapt to a continuously changing scientific and technological world must be a high priority in K–12 education.

Science education is for all students. The expectations for what students should know and be able to do in a cultural context are identified through national and state standards. These expectations include understanding what it means to "do" science, recognizing the historical significance of science achievement and ethics underlying these achievements, and viewing science from the human dimension, that is, understanding the relationships between science and society.

State standards documents provide frameworks for each state's educational system. Formal and informal assessments aligned with state standards provide evidence of student achievement and offer valuable information to guide the teaching and learning process.

Instruction is the collective process through which the messages of the standards "come alive" through rich and meaningful experiences that focus on observation, reason, experimentation, sense making, and reflection. Instruction, to be effective, must engage students and motivate them to seek answers to their questions. Just as students exhibit an array of biological and cultural differences, so, too, classroom instruction must be diverse and include an assortment of methods and strategies to accommodate different ways students learn and know. As such, instruction is a creative process providing students a wide range of learning opportunities enabling them to understand or seek to understand complex subject matter and transfer learning to new problems and contexts. Student interest and motivation are enhanced through active and meaningful learning.

DIFFERENTIATED INSTRUCTION

What is differentiated instruction? Differentiated instruction is an approach to strategic planning of classroom instruction that meets the needs of all students. Differentiated instruction enables students to build a meaningful and accurate knowledge base, develop skills needed to become scientifically and technologically literate, and practice dispositions that are valued in the society. Differentiated instruction requires carefully designed lessons that align with important goals and standards and include a variety of methods and strategies to meet the needs of students.

Why do we use it? The classroom is viewed as a community of learners where teachers and students share responsibility for learning and work collaboratively to construct knowledge, develop skills, and practice dispositions. Differentiated instruction allows students to be physically and mentally involved in creating personal and meaningful learning and enables teachers to facilitate and guide the learning process to better meet the needs, interests, and ability levels of students.

What does it look like? An "environment of active learning" would best describe the differentiated classroom. Instruction focused on important goals and standards may be designed around assessment feedback and student needs, readiness for learning, learning profiles (ways of learning and knowing), and cultural contexts.

Instruction may involve the total group or be designed to enable small groups and individuals to work in varied ways to learn important concepts and skills. The teacher's role is that of facilitator—monitoring and guiding instruction, interacting with students, and mediating learning.

TEACHING MATTERS

Recent research emphasizes the importance of high quality classroom instruction for increasing student achievement in mathematics and science.

1. A study by Educational Testing Service found that while teacher inputs, professional development, and classroom practices all influence student achievement, the greatest role is played by classroom practices (Wenglinsky, 2000).

The study showed a positive correlation between teacher quality and higher student achievement in both math and science, and pointed to the need to improve classroom aspects of teacher quality. For example, teachers need to convey higher order thinking, engage students in active learning, and use assessment data to monitor student progress.

2. A study of K–12 mathematics and science education in the United States identified indicators of effective lessons and used these criteria to assess instruction in 350 math and science classrooms. In this study, exemplary instruction was defined in these ways:

- Instruction is purposeful and all students are highly engaged most or all of the time in meaningful work (e.g., investigations, teacher presentations, discussions with each other or the teacher, purposeful reading).
- The lesson is well-designed and artfully implemented, with flexibility and responsiveness to students' needs and interests.
- Instruction is highly likely to enhance most students' understanding of the discipline and to develop their capacity to successfully "do" mathematics or science (Weiss, 2003).

Clarifying Instructional Goals

In *Science for All Americans*, the American Association for the Advancement of Science recommends that all students leave school with an awareness of what the scientific endeavor is and how it relates to their culture and their lives (American Association for the Advancement of Science, 1989).

The National Science Education Standards offers four goals for school science that relate to the cultural context, as well. The goals are designed to enable students to do the following:

- Experience the richness and excitement of knowing about and understanding the natural world.
- Use appropriate scientific processes and principles in making personal decisions.
- Engage intelligently in public discourse and debate about matters of scientific and technological concern.

- Increase their economic productivity in their careers through the use of the knowledge, understanding, and skills of the scientifically literate person (National Research Council, 1996, p. 13). In traditional science programs, emphasis is given to concepts and principles of life, earth/space, and physical science, with little attention given to the other content standards: unifying concepts and processes, science as inquiry, science and technology, science in personal and social perspectives, and history and nature of science.

Courses steeped in expository methods do not promote the development of critical and creative thinking, problem solving, and decision making. More recently, brain research, advancements in technology, awareness of differences in learning styles, and theories related to intelligence have focused on the importance of providing varied pathways to learning and making science relevant by applying it to the lives of students and the technological world in which they live. Through a climate of active engagement and risk taking that promotes thinking and problem solving, students are more likely to acquire the knowledge and develop the skills they need to be successful throughout their lives.

DIFFERENTIATED INSTRUCTION IN ACTION

The goals of science education can be achieved only through carefully crafted instructional programs that are aligned with standards and goals and facilitated by teachers who have the knowledge, flexibility, and resources to accommodate the varying needs and interests of a diverse population of students. The purpose of this book is to provide a model for planning, organizing, and facilitating high quality instruction based on the eight National Science Education content standards to meet the needs of learners. It is not possible to address the full range of standards in the examples provided in the text, but efforts are made to emphasize the importance of addressing all of them throughout the K–8 science program.

The planning guide found on Figure 3 in Chapter 1 was designed from the model for instruction from *Differentiated Instructional Strategies: One Size Doesn't Fit All* (Gregory & Chapman, 2007) and the model for high quality instruction in science from *Becoming a Better Science Teacher: Eight Steps to High Quality Instruction and Student Achievement* (Hammerman, 2006a). The planning guide provides a framework for instructional design that enables teachers to carefully consider each step in the instructional sequence and make decisions regarding the use of the many strategies for differentiating instruction to accommodate the needs, interests, and ability levels of their students.

Selecting a variety of appropriate methods and strategies for student engagement and success is the key to promoting student achievement. Flexibility throughout the instructional process is critical as assessments of student progress may require changes, modifications, or additions to the original plan.

Figure 1 identifies the topics around which each of the chapters in this book was developed. Information, resources, methods, and strategies are offered to enable teachers to use the planning guide to create student-centered instruction that addresses standards in ways that accommodate the needs of a variety of learners.

Figure 1 Understandings, Tools, and Strategies for Differentiating Instruction in Science

Creating a Climate for Differentiated Instruction	Scientific and Technological Literacy for the 21st Century	Knowing the Learner	Methods and Effective Practices for Increasing Student Achievement	Strategies for Activating and Engaging	Strategies for Acquiring and Exploring	Strategies for Explaining, Applying, and Creating Meaning	Strategies for Elaborating and Extending Learning	Strategies for Assessing and Evaluating Learning
A Climate for Learning A Safe and Enriched Environment Natural Learning Systems • Emotional Learning System • Social Learning System • Physical Learning System • Cognitive Learning System • Reflective Learning System A Planning Guide for Differentiated Instruction Phases of the Planning Model	Scientific Literacy Science Education Standards Unifying Concepts and Processes Process and Thinking Skills in K–8 Science Dispositions That Underlie Science Dimensions of Learning Technological Literacy Integration of Information and Communication Technology (ICT)	Multicultural Education Multicultural Education in Science Gender Equity and Gender Equity in Science Learning Modalities Learning and Thinking Styles Models of Learning and Thinking Styles Gardner's Theory of MI Intelligences Linked to Science Properties of Earth Materials Aligned With Multiple Intelligences Sternberg's View of Intelligence Strategies for Presssessment	Methods for Teaching and Learning Science The Roles of Teachers and Students in Methods Research-Based Effective Practices Strategies Linked to Brain Research and Classroom Practices • Science Notebooks • Lab Reports • Grouping • Cooperative Learning • Adjustable Assignments • Curriculum Compacting	Strategies for Engagement • K-W-L Charts • Discrepant Events • School Site Investigations Informal Learning Environments • Video Clips • Guest Speakers • Displays • Literature • Case Studies	Inquiry Defined Traditional Versus Inquiry-Based Classroom Factors That Support Inquiry and DI in Science Problem-Based Learning Projects, Products, and Presentations • Booklets, Posters, and Brochures • Science Fair Projects Stations Centers Choice Boards Contracts Computer-Based Technologies for Learning	Group Discussion • Questions for Thinking and Problem-Solving Nonlinguistic Representations • Charts • Data Tables • Graphs Graphic Organizers Four-Corner Organizer	Beyond the Basics Games that Enhance Learning • Cubing • Jigsaw Analogies and Similes	Assessment Toolkit • Observation Checklists • Interviews • Notebook Entries • Teacher-Made Tests • Products and Projects • Performance Tasks • Criterion Referenced Tests and Quizzes Creating Rubrics for Teacher Assessment and Student Self-Assessment • Holistic Rubrics • Generalized Rubrics • Analytic Rubrics Planning: The Key to Success