Nationally and internationally, educators now understand the critical importance of STEM subjects—science, technology, engineering, and mathematics. Today, the job of the classroom science teacher demands finding effective ways to meet current curricula standards and prepare students for a future in which a working knowledge of science and technology will dominate. But standards and goals don’t mean a thing unless we:

• grab students’ attention;
• capture and deepen children’s natural curiosity;
• create an exciting learning environment that engages the learner; and
• make science come alive inside and outside the classroom setting.

A Guide to Teaching Elementary Science: Ten Easy Steps gives teachers, at all stages of classroom experience, exactly what the title implies. Written by lifelong educator Yvette Greenspan, this book is designed for busy classroom teachers who face tough conditions, from overcrowded classrooms to shrinking budgets, and too often end up anxious and overwhelmed by the challenges ahead and their desire for an excellent science program.

This book:

• helps teachers develop curricula compatible with the Next Generation Science Standards and the Common Core Standards;
• provides easy-to-implement steps for setting up a science classroom, plus strategies for using all available resources to assemble needed teaching materials;
• offers detailed sample lesson plans in each STEM subject, adaptable to age and ability and designed to embrace the needs of all learners; and
• presents bonus information about organizing field trips and managing science fairs.

Without question, effective science curricula can help students develop critical thinking skills and a lifelong passion for science.

Yvette Greenspan received her doctorate degree in science education and has developed science curriculum at all levels. A career spent in teaching elementary students in an urban community, she now instructs college students, sharing her love for the teaching and learning of science. She considers it essential to encourage today’s students to be active learners and to concentrate on STEM topics that will help prepare them for the real world.
A Guide to Teaching Elementary Science
I dedicate this book to the many teachers I have known who have overcome tremendous obstacles to tirelessly inspire their students to love all that is science.
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PREFACE

PURPOSE OF THE TEXT

This book presents ten easy steps to help veteran, experienced, and novice teachers develop a sound, realistic, fun and exciting science curriculum within the guidelines of the Next Generation Science Standards and the Common Core Standards. It is:

• designed as a practical handbook for busy classroom teachers;
• organized to include best practices for teaching science;
• structured with easily implemented ideas and lesson plans that embrace and address the needs of all learners;
• prepared with extensive lists of resources.

The steps are designed with inquiry learning, thus engaging all students in the learning process through hands-on activities in cooperative learning groups. I wrote this book using everyday language and with simple descriptive examples that are thought-provoking and supported by leading researchers and verified by my extensive experience.

HOW TO BEST USE THIS GUIDEBOOK

Using this book will not consume large amounts of your time. As an elementary school teacher, I understand that your time is valuable and limited. That's why I designed this book to use before, during, or after you teach a science lesson or to peruse when it’s convenient for you to reflect on the notion of how to teach science when your students are excited and motivated to learn.

ORGANIZATIONAL FEATURES OF THE TEXT

Part I

Rooted in the Next Generation Science Standards, the ten steps, basic and uncomplicated, are easily read and should prepare you to teach science through inquiry-based learning, the 5E Instructional Model, and the Scientific Method. Think about them in planning your science lessons and setting up effective science curricula. Take the ideas outlined and adapt them to the needs of your students and to your own needs as a teacher. Try them – they may not work effectively at first, but with time, you might find them helpful and worthwhile.
Part II

Part II of this book is devoted to sample lesson plans, which cover each of the areas of science required by the current standards. You will see lesson plans for both primary and intermediate grades in physical science, life science, earth and space, and engineering, technology and applications of science. Not only do they follow the 5E Instructional Model, a possible approach for teaching inquiry learning, emphasizing STEM, each lesson plan contains background information on the scientific concept, materials needed to teach each topic, the five phases for teaching the concept, possible home learning assignments, strategies to teach the Exceptional Student (ESE learners), some connections to other disciplines, and several real world applications. I have also included some of my favorite lesson plans. They, too, may be adapted, revised, and adjusted to meet the needs of your students. The unit on a place-based experience, a field trip, gives you science content in the disciplinary core ideas found in the Next Generation Science Standards and also integrates mathematics, social studies, and language arts’ skills. The handouts are excellent teaching tools and can be adapted, too, for all grade levels.

Figures, Handouts and Appendices

The figures found throughout this guidebook and other handouts exhibited in the appendices should help you to incorporate the ten steps, always remembering that “nothing is written in stone;” the steps serve only as a source of information and a foundation to build on as you pursue new avenues of teaching. You’ll find handouts for a science fair, including an elementary assessment, and other assessments I have used in my classroom and found to be most effective. Keep in mind that every handout can be adapted for your grade level and the ability of your students.

A Final Note

Take into consideration the ten steps outlined in this handbook. Add them as another source of information to help your students learn science. I believe they can only improve your teaching and your students’ learning. As you embark on this new journey, or perhaps continue it, think of it as an exciting path toward greater understanding of all that is science.
ACKNOWLEDGEMENTS

Thank you to all the college professors, educators, administrators, mentors, and teachers who have inspired me to develop a passion for both learning and teaching science. I have learned from all of you.

Thanks also to my editor, Virginia McCullough, for her patience, expertise, and belief in my ability to complete this project. She has taken my words and made them vividly real so that they can benefit the educational community.

Thank you to Peter de Liefde and the staff at Sense Publishers for having confidence in me and for providing support and assistance in the editing, proofreading and design of this book.

Thank you to my family and friends who have encouraged me throughout this journey. You know who you are!

And, of course, I want to thank my husband and my children for their love, understanding, and constant reassurance during the many hours it took me to write this book and complete a lifelong goal.

Finally, to my grandchildren, who are learning that the world of science is all encompassing and plays an integral role in their everyday life: May you always be motivated and encouraged to observe, explore, learn, study, and research the true meaning of science.
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INTRODUCTION

In a world filled with the products of scientific inquiry, scientific literacy has become a necessity for everyone. Everyone needs to use scientific information to make choices that arise every day. Everyone needs to be able to engage intelligently in public discourse and debate about important issues that involve science and technology. And everyone deserves to share in the excitement and personal fulfillment that can come from understanding and learning about the natural world.1

Teaching science should be fun and rewarding. Based on the premise that children have a natural curiosity about the things around them, teaching science would seem to be an easy task. Children wonder how plants grow and how animals live and move in their environment. They ask about how birds can fly and how high the sky stretches above them. They want to know why the moon glows and why it rains. So, given the nearly universal curiosity we see in children, why do some teachers have difficulty creating a classroom in which all students are engaged and enthusiastic about science learning? Based on my experience, many pre-service teachers and novice teachers, along with some veteran teachers, too, lack the know-how to create an active learning environment that promotes students’ innate inquisitiveness, especially in culturally diverse classrooms.

In an effort to fill a gap in teaching tools, I created this practical, step-by-step handbook to provide guidelines to help you reach your goal of a successful science classroom for all learners. Regardless of experience level, pre-service or veteran, every reader will come away with a foundation of strategies that provide ideas to think about now and in the future.

Although I’ve designed the steps sequentially, you can adapt them to fit your teaching style, perhaps combining several steps or use them individually. I’ve also used the language, the ‘jargon’, of our profession. In addition, my purpose here is not to provide an abundance of details about every science classroom strategy. Rather, I chose to offer a brief course of action to heighten the awareness of science for both teachers and students. “After all, the ideal is to involve the students in their own learning while recognizing their prior experiences and encouraging them to be active learners.”2
INTRODUCTION

THE CURRENT STATE OF STUDENTS’ SCIENCE PERFORMANCE

We see significant evidence indicating that when compared to children learning science in other countries around the world, students at various academic levels in the United States are not adequately learning basic science. The former president of the National Science Teachers Association (NSTA) remarked that learning science is an on-going process that begins in elementary school. She states:

...teachers are often surprised to find middle school and high school students have major misconceptions about fundamental ideas developed early on that went unchallenged through school. They are also dismayed to find there are often large gaps in students’ conceptual understanding for even basic ideas in science. Is it reasonable for a school district to eliminate science for six years and then expect students to fill in the blanks in middle and high school? Science learning is a cumulative process.3

What about the state of science education at the college level? According to a 2014 article in The New York Times, Pérez-Peña concludes that students do better with a more active approach to learning science. He notes that after science educators overhauled the teaching strategies of an introductory physics class at the University of Colorado, students’ scores improved approximately fifty percent more than those classes taught in traditional fashion. Similar results were found at the University of North Carolina in introductory biology classes. Further, the new strategies proved more beneficial for black students and those whose parents did not go to college.

Given these findings, it seems evident that our colleges should reinvent the way they teach science. However, generally speaking, this isn’t the trend. Some explanations reveal that many tenured professors prefer to teach by lecturing and do not like to change what they believe works for them. Therefore, they find it difficult to create a classroom that is more student-oriented, one in which students work in teams and that incorporates new technologies. Pérez-Peña says, “At four-year colleges, 28 percent of students set out as math, engineering and science majors, but only 16 percent of bachelor’s degrees are awarded in those fields.”4 Perhaps it’s time to rethink how we teach science at the college level.

ASSESSING SCIENCE ACHIEVEMENT

One of the ways we examine science achievement is through assessments administered nationally and internationally. The “Trends in International Mathematics and Science Study (TIMSS)” is a series of international assessments of the mathematics and science achievement of students around the world. Since 1995, the assessment has been given internationally to fourth and eighth-graders every four years. The TIMSS suggests that when compared to students in other countries, fourth graders in the U.S. have shown no significant detectable change in science achievement during
INTRODUCTION

that timeframe. For eighth graders, the trend appears more positive but our U.S. students’ scores still lag behind the front running Asian countries.

What do these results say about our science teaching at these grade levels? We have to ask ourselves if as teachers we’re preparing our students to meet the demands of competing in the twenty-first century technological world. Are we addressing all of the needs of our minority students, who currently comprise 36% of our population, but make up more than half of all children born in the U.S. today?

THE ACHIEVEMENT GAP

Why do we continue to see these disappointing test results? Although it is difficult to pinpoint one particular reason, a science achievement gap still exists among minority students and others students from diverse cultural backgrounds. According to the No Child Left Behind Act of 2001, all students were required to achieve high academic standards in core subject areas. However, although recent outcomes indicate that test scores have improved, a gap remains between white students and African American and Hispanic students, especially in the upper grades.

Furthermore, Fensterwald concludes that the gap starts early in elementary school, widens in middle school, and continues, through filters and barriers, on a trajectory of low achievement and missed opportunities for minority groups. He claims that by the end of college, the number of Latinos and African Americans who graduate with degrees in science, technology, engineering, and mathematics is a trickle of the population.

In addition, we see a relatively stable science achievement gap in the way Hispanic students perform as compared to white students, with white students outperforming Hispanic students. Researchers explain that teachers appear to be unprepared to meet the learning needs of English-language learners because they have not received significant professional training in cultural differences. According to Bryan and Atwater:

If teacher education programs do not assist science teachers in uncovering and critiquing their beliefs about students and teaching, we will continue to have teachers who rely on their cultural models that contain negative stereotypes (beliefs) and prejudices (attitudes) about culturally diverse students, their parents, and communities. “Science for all” will not become a reality for all U.S. students.

Others agree that teachers who are inadequately prepared to teach science or use its teaching strategies are faced with a growing number of English Language Learners (ELL) in their classrooms. These students “frequently confront the demands of academic learning through a yet-unmastered language without the instructional support they need.” Therefore, in order to improve the science literacy of their ELL students, teachers need professional development intervention to “improve
INTRODUCTION

their knowledge and practices in teaching science while promoting English language development of ELL students in urban schools.14

Moreover, according to Parsons, African American students, the second largest minority group in the United States, perform poorly in science achievement in the early grades, a trend that becomes more pronounced as they reach high school. Based on her findings, she found that culturally congruent instruction and the context in which African Americans learned science affected their success in that subject. In her article, she analyzes the cross-cultural work of Au and Kawakami, who connect culture, context, and learning by incorporating the ethnic minorities’ culture into the education process. She contends that teaching content to these students should contain relevant cultural examples along with meaningful strategies.15

Others agree that we see a declining number of African American students in mathematics and science, particularly in STEM related fields. The reasons for this decline include perception of those subjects, lack of mentoring, stereotyping, and economic shortfalls.16 On a more positive note, however, in recent years dropout rates have fallen steeply for all minority groups, including African American, Hispanic, and low-income young people; college attendance among the same groups has jumped sharply. Still, in 2014, students from low-income families complete college at only one-seventh the rate of those from high-income families.17

Not only are African American students and Hispanics not achieving the kind of success needed to understand basic science concepts, but girls also fall into this category. Patrick, Mantzicopoulos, and Samarapungavan noted that according to the United States Department of Education, girls are underrepresented in degrees earned and careers related to physical science, computer and information science, and engineering. Because girls are less likely to study science-oriented subjects and don’t select non-compulsory science classes in high school, they have minimized their opportunity to access high-paying careers.18 Furthermore, St. Rose states, “it is true that women are underrepresented in high-paying jobs, like those in science, technology, engineering and mathematics (STEM) fields. But it’s not that simple as women not choosing STEM – they’re often actively discouraged from pursuing careers in those fields.”19

What, then, discourages girls? What influences girls’ motivation (or the lack of it) to learn science? In a research study conducted in a large urban community, elementary school girls in third and fifth grade were observed learning science in a classroom setting with boys and other girls. Observers noted that cultural and societal factors had an appreciable effect on how girls appeared to have learned science. The qualitative study included observations, interviews, and a questionnaire; the results mirrored previous studies, which indicated that girls are generally conscious about their interrelationships with boys; this then affects their self-perception and the way others perceive them. As a consequence, girls modify their behavior and alter the way they learn science.20 This is certainly a possible influence that discourages girls to choose science related careers.
A CALL FOR ACTION

Given the performance among all students in the U.S. and the gap among certain groups of students, I call upon you to act now and cultivate a love for all things science. It’s within your power to help your students improve their knowledge of science, enrich the process of understanding science, develop their ability to think critically, and facilitate their proficiency in connecting and applying science concepts to everyday life. As professionals, it’s our responsibility to enhance science learning for every student, whatever their race, culture, or gender. We are called on to foster students’ natural curiosity so that they can reach their full potential and acquire the necessary science skills to live productively in the twenty-first century. Without a doubt, children from all backgrounds are capable of being successful in science.21

This ten-step handbook is designed as a tool to help you expand your views on science education and develop curricula that include the process of inquiry-based science. These ten steps will help you create a learning environment that emphasizes hands-on discovery and exploration of scientific concepts. Consider this a guide, which when implemented should help you create a classroom setting that is fun and engaging for all your students. Follow these ten easy steps I’ve outlined and you and your students can grow together toward understanding your scientific world.

NOTES


INTRODUCTION


PART I

TEN EASY STEPS
CHAPTER 1

STEP ONE

Know What You Want to Accomplish

The important thing in science is not so much to obtain new facts as to discover new ways of thinking about them.

William Lawrence Bragg

Science is complex to teach, in no small part because it’s always changing. Your first priority is understanding the content you’re about to teach. (If you are not familiar with the science concept at hand, use the resources mentioned below.) However, it’s fine to learn along with your students, and they’ll admire you for living the reality that scientific knowledge is expanding rapidly. After all, the ideal classroom is one in which the students and teacher grow and evolve into a community of learners.¹

Ask yourself what you want to learn about the concept, what content is required, and your students’ current level of understanding of the topic. As you develop your students’ curiosity, try to widen yours. If possible, read books and magazines on the topic, research current practices, use students’ textbooks or your Teacher’s Guide as a reference, discuss the topic with colleagues, browse the Internet, and attend professional development workshops. All of these will help you prepare for what you want to accomplish.

ORGANIZE AND PLAN

Organizing and planning your lessons are the most important and time-consuming tasks involved in teaching, whether the subject is language arts, mathematics, social studies, or science. However, gathering the tools and planning lessons to meet your objectives are necessary steps to ensure success. (Check out suggestions for inquiry learning and the lesson plan format for the 5-E Instructional Model detailed in Step Five).

PLANNING A SCIENCE CURRICULUM

The groundwork for all science lesson planning is derived from the National Science Education Standards, published in 1996. “Standards are not a curriculum. They are not a set of lesson plans. They are goals for achievement that are appropriate for all members of the science education community.”² Most recently, the Next Generation Science Standards were released; their goal is to better prepare students to think
critically, engage them in more relevant context, and apply science to their daily lives. The Standards are divided into three main areas:

1. **Performance expectations**: Performances that can be assessed to determine if students meet the standards on what they should know and understand.

2. **Disciplinary Core Ideas**: Each performance expectation incorporates disciplinary core ideas (physical science, life science, earth and space, engineering, technology and applications of science), cross-cutting concepts (patterns, cause and effect, systems, energy, structure, and stability), and a science and engineering practice.

3. **Connections to other ideas and Common Core**: Each set of performance expectations lists connections to other ideas within science and engineering, and with the Common Core State Standards (see below) in mathematics and language arts.

By following the guidelines set forth in these Standards, teachers know what they need to accomplish in their science classrooms.

In addition, statewide standards, those known as Common Core Standards, were developed by a team of educators that included teachers, administrators, and national organizations. Their mission was to upgrade state standards by adopting a common core of internationally benchmarked standards in mathematics and language arts for grades K-12. The objective of the Common Core Standards is to ensure that students of that state become equipped with the necessary knowledge and skills in mathematics and language arts to be competitive globally. Although the Common Core Standards are not yet written for science, expectations are that science content would be integrated into the teaching of both mathematics and language arts.

Next, consider how you’ll plan your lessons. Develop a unit of study, a series of easy-flowing and sequentially-targeted lessons, which correlate with the Next Generation Science Standards and the Common Core Standards mentioned above. Both the National Research Council and the Institute for Inquiry recommend that the goals or outcomes for most science lessons should focus on teaching both science content and the science process skills (now referred to as Practices in the Next Generation Science Standards): observing, measuring, inferring, classifying, predicting, and communicating (see Step Seven). Plan ahead, always remembering that your planning depends on the cognitive and maturation levels of your students. Consider a format for lesson development, incorporating inquiry-based learning, which includes the five phases of engagement, exploration, explanation, elaboration, evaluation (discussed in Step Five).

By the same token, try to organize your investigations/experiments during your planning periods, a time when students aren’t present. Further, prepare well in advance with all materials you need to conduct the investigation. Good preparation decreases stress and promotes a safe learning environment that ensures maximum learning. At the time you present the lesson itself, your materials should be ready to distribute to your students. Your preparation then gives you ample time to interact with your students and guide them through the learning process.
Finally, try to be flexible. Think about all the issues that could affect your curriculum, from planning your lessons, gathering your manipulatives, and/or organizing your experiments. You may need to be flexible in any number of areas to accommodate your students’ needs. Students’ classroom behavior and their readiness to learn, potential parent requests, and possible administration directives might call on you to modify your lesson plan as you teach. When time is short, you may need to change your plan and complete the topic at another time or make changes to teach it in the next hour or the next day.

In addition, be flexible if the manipulatives you need to conduct an experiment aren’t immediately available – they could be hidden in closets, cabinets, or boxes in other classrooms in the school (see Step Six). If you need to, tap into the resources at your school; ask administrators, other teachers, or even your students if they know where the materials are located.

If the tools you need for conducting a particular lesson are unavailable, solicit donations from local businesses or check the catalogues of various scientific companies, such as:

- Carolina Biological Supply  www.carolina.com
- ETA Hand2Mind  www.hand2mind.com
- Frey Scientific  www.freyscientific.com
- Explore Learning  www.explorelearning.com
- Pasco Scientific  www.pasco.com

Of course, request monetary help from your administrator before purchasing the manipulatives, or ask your students’ parents to donate the materials (see Step Six). You’ll experience much less frustration if you take steps to acquire the materials your students need for their experiments.

KEY POINTS

- Know what you want to accomplish in your science curriculum.
- Find out what you need to learn in order to teach a specific scientific concept.
- Develop a curriculum aligned to the Next Generation Science Standards or the Common Core Standards.
- Create lesson plans that include inquiry-based learning, and, most importantly, be flexible during your planning time and in your teaching.

NOTES

CHAPTER 1


CHAPTER 2

STEP TWO

Set the Stage

Imagination is more important than knowledge.
Albert Einstein

Setting the stage or creating an atmosphere that promotes a love of learning is as important as planning a viable science curriculum. Being familiar with each of your students helps you become aware of the many factors that affect how they learn in the classroom. In addition, when teachers present a scientific concept, they must address misconceptions students already have about the topic. As Bransford, Brown and Cocking note, “Before students can really learn new scientific concepts, they often need to re-conceptualize deeply rooted misconceptions that interfere with the learning.”

In other words, as we experience and observe the physical world, we construct a view that we stubbornly stick to whether or not it conflicts with scientific concepts. One example would be the way we think about a leaf and rock falling to the ground. Most of us reason that the rock falls faster than a leaf because it is heavier and the leaf is lighter. As we think about Newton’s apple falling from the tree, we now know that a heavier object does not always fall to the ground more quickly than a lighter object because when dropped from the same height, objects fall to the earth at the same time when no major amount of air mass is acting upon them. Once we actually perform the task, we realize that our understanding is incorrect and we are forced to accept a new view.

THE CONSTRUCTIVIST LEARNING THEORY

Using the Constructivist Learning Theory as a guide, we can assume that individuals build knowledge based on previous experiences, constructed by making sense of these personal experiences in a social context. In other words, learners construct their own knowledge and develop meaning based on that knowledge. That’s why a pre-knowledge phase gives the teacher an awareness of what the student knows at the onset. Let’s think about the impact of a heavier moving truck colliding with a small car. Most know, based on their experiences, that the truck will do much more damage to the car just because it is bigger and, therefore, in their thinking, can exert a larger force. However, Newton’s Law states that two interacting bodies exert equal and opposite forces on each other. Therefore, students should be given opportunities
to explore such misconceptions together to change their initial construct and cultivate a new one.

In the final analysis, this pre-teaching phase allows the teacher to understand what drives a student to understand a science concept. The teacher can then correct students’ ideas and guide them toward a better comprehension of the goals of the lesson and, at the same time, students can take on the responsibility to move forward and learn the concept.

TEACHER EFFICACY

Let’s consider the student/teacher roles. The student is expected to cooperate, become an active learner, and complete the task. However, what should we expect from teachers in a student-oriented learning environment? According to Ashton there are two components to teacher expectations:

• the teacher believes that students, generally speaking, can learn the material.
• the teacher believes that some of these students can learn under his or her direction.

Ashton further reports there are eight dimensions to the development of teacher efficacy:

| 1. A sense of personal accomplishment | The teacher must view the work as meaningful and important. |
| 2. Positive expectations for student behavior and achievement | The teacher must expect students to progress. |
| 3. Personal responsibility for student learning | Accepts accountability and shows a willingness to examine performance. |
| 4. Strategies for achieving objectives | Must plan for student learning, set goals for themselves, and identify strategies to achieve them. |
| 5. Positive affect | Feels good about teaching, about self, and about students. |
| 6. Sense of control | Believes (s)he can influence student learning. |
| 7. Sense of common teacher/student goals | Develops a joint venture with students to accomplish goals. |
| 8. Democratic decision making | Involves students in making decisions regarding goals and strategies. |

Based on Ashton’s beliefs about teacher effectiveness and expectations, the notion evolves that students take responsibility for their own learning while teachers provide the necessary manipulatives and tools with which to discover and learn. In
other words, the teacher, as a guide, establishes a community of learners that expects students to engage with each other and ultimately succeed in learning science.

QUESTIONING TECHNIQUES

The manner in which teachers approach questioning students is key in determining if a student understands a concept or simply recalls information. This is the reason questioning strategies should be open-ended and provoke thought, enhance critical thinking, and give the teacher access to how students think. Once you know their ideas, you can encourage students to test them. The way a teacher forms a question and then responds to an answer also determines if the students are comfortable enough to openly express themselves.

Manktelow and Carlson define questions as either closed or open. A closed question requires a simple response of yes or no, or it might be answered with a short response. A closed question tests students’ understanding or concludes a discussion; these kinds of questions also can stop a conversation and create long silences. On the other hand, an open question requires the student to think about the response. These questions usually begin with what, why or how, but they could also start with a phrase or word that implies expansiveness, such as “tell me,” or “describe.” An open question elicits students’ knowledge, opinions, or feelings and encourages them to provide details and further explore other issues.

According to Exploratorium we can identify four categories of questioning in inquiry learning:

• Subject-centered, in which only one correct answer is possible.
• Person-centered, in which no wrong or right answer exists because the question asks what the student thinks.
• Process-centered, in which students must do something, using process skills, such as observing, measuring, inferring, and classifying.
• Other skills that do not fit into any of the above categories.

Obviously, an inquiry-based learning environment should emphasize more person-centered and process-centered questions.

Keep in mind that questions provide more than information about what students are learning. Open questions also help:

• build a bond between teachers and students;
• both teachers and students reflect on the topic;
• guide students through their misconceptions and eliminate them; and
• encourage students to embrace new ideas.

Ask open-ended questions in both small group discussions or with the whole classroom group, and in either case, use visual graphic organizers (see Step Four) to begin a dialogue. Or, use questions to start a brainstorming session on a specific topic such as push/pull, living/nonliving, sink/float, evaporation/condensation, and so forth.
CHAPTER 2

Equally important to asking the right kind of question is the manner in which a teacher responds to a student’s answer. For example, if you respond by saying, “any questions?” or “is that clear?” or “okay?” you’re inadvertently telling your students that they shouldn’t have any questions and deadens further discussion. Better to say, “I bet you have some questions now – maybe I can answer them!” This implies that you’re interested in what they have to say.

When addressing questions, first focus on the entire class rather than the individual student so that the student is not singled out. Next, be positive, direct, loving, constructive, encouraging, and helpful. If the question is a good one, tell the student as much; if the response is off task or inconsequential to the topic, respond with a different kind of statement, such as: “That’s very interesting,” “I like what you’re saying,” or “Let’s talk about that later.” Finally, if you’re unsure about a response or simply want to involve your students in the process, throw the question back to them.9

DEVELOP A SCIENCE DISCOURSE

Many researchers have studied the importance of teachers and students discussing scientific concepts together, either in a whole class setting or in small groups. For example, Gallas10 describes the way implementing “talking science” can transform the way we teach science and over time, changes the teacher’s role. She views classroom science as a place for discourse, with its own language and thinking practices and describes the outcome for students in this child-centered approach. In other words, when students discuss the language of science throughout the learning process, it enhances their understandings of scientific concepts and provokes further thought.

ENHANCE STUDENTS’ NATURAL Curiosity

Along these same lines, you can set the stage by enhancing your students’ natural curiosity; they already have an innate desire to learn about the world first-hand, which is why it’s important to provide ample and meaningful opportunities to develop a love of learning science. Their eagerness to explore and discover is inherent, but as they observe and experience the world, they may develop misconceptions. For example, based on observation alone, they may conclude the sun rises in the morning at the same place, or the same stars appear in the sky every night, seasons are caused by the distance between the earth and the sun, the moon can only been seen at night, mass and weight are the same, and rocks must be heavy.11

Teachers should provide many hands-on activities so students can work through their misconceptions, change their beliefs, and reconceptualize their views. As they face these challenges and learn to solve problems effortlessly, students can apply the process to real-world situations.
KEY POINTS

- Guide students through their misconceptions as you encourage their curiosity about the world around them.
- Be mindful of the environment – the atmosphere – you create in your classroom.
- Stimulate science discourse through open questions and the manner in which you respond to their answers.
- Inspire your students to love science by using their inherent curiosity about the world.

NOTES