Research-Based Curriculum

Discovering Science through Inquiry

Complete Supplemental Program

Based on Respected Research & Literature
Research-Based Curriculum

Discovering Science through Inquiry

Introduction

Science has always been a cornerstone of America’s education system. Renewed calls for more science instruction in today’s schools have arisen since the implementation of NCLB with its intensive focus on reading and math achievement. Many educators lament the limited time they have to teach science given the constraints of federal policy. However, the benefits of effective science instruction are obvious. Education, business, and political leaders have called for more science instruction in an effort to boost America’s economy and ensure continued technological innovation. In 2000, the Glenn Commission, led by Senator John Glenn, called for more effective science and math instruction in order for the United States to remain a global leader. In the Commission’s report, Senator Glenn stated, “We as a nation must take immediate action to improve the quality of math and science teaching in every classroom in this country. If we delay, we put at risk our continued economic growth and future scientific discovery” (U.S. Department of Education, 2000).

Such calls for improved science instruction revealed a need for educators to have the curriculum resources necessary to effectively teach science. Discovering Science through Inquiry was created to provide research-based lessons for teachers. The program is based on current research for science inquiry methodology and instructional practices for meeting the needs of diverse learners. The materials are designed to develop students’ scientific literacy skills, while also motivating students through engaging content.

The Need for Effective Science Instruction

International Achievement Comparisons

Many points in American history have declared the need for students to improve their performance in science. The 1960s brought on the space race, which led to increased focus on math and science instruction in America’s schools. Government reports of the 1980s such as A Nation at Risk (United States, 1983) lamented American schools as failing their students. These reports highlighted the failure of American students to score above their Japanese and Russian counterparts. In the 1990s the Third International Math and Science Study (TIMSS) results showed American students performing below most industrialized nations, and even some unindustrialized ones (Martin, et. al, 2000). These results shocked American educators into focusing more on science and math instruction. Today, Americans continue to score below other nations on exams such as TIMMS and the Program for International Student Assessment (PISA) (Organization for Economic Cooperation and Development, 2006). These results continue to ignite calls for improved student learning in science.
21st Century Skills

“Having a basic knowledge of scientific principles is no longer a luxury but, in today’s complex world, a necessity” (Miller, 2007). The American Association for the Advancement of Science (AAAS) began Project 2061 in order to develop and promote science literacy. The project was established with the understanding that simply offering more science content is not effective. Rather, it is more important to teach the essentials of science content more efficiently (AAAS, 1989). The authors of the paper stated that most Americans are not “science literate” and that U.S. students do not rank well in comparison to other nations in science and mathematics (AAAS, 1989). Shortly thereafter, the Association developed benchmarks for science literacy that have been used in the development of state standards. As Americans become more knowledgeable about the basics of science content, this can lead to a more sophisticated work force, better consumers, and wiser influences on public policy as it relates to scientific issues. (Miller, 2007) Clearly, there is a need for students to be educated in science concepts.

Diverse Learners

Diversity in America’s public schools is a fact. This diversity spans over many languages and cultures. “Each year, the United States becomes more ethnically and linguistically diverse, with more than 90 percent of recent immigrants coming from non-English speaking countries” (Echevarria, Vogt, and Short, 2004). In U.S. classrooms, there are over three million students who are English Language Learners (NCLB, 2001). Nearly every major city in every state in the country has multilingual, multicultural student populations (Calderon, 1997). One researcher predicted in 1992 that by the year 2056, most U.S. citizens would be able to trace part of their heritage to Africa, Asia, the Hispanic countries, and the Pacific Islands — to places that were not “white Europe” (Wittmer, 1992). Many other researchers have continued to make similar predictions about the growing demographic changes in U.S. schools.

Beyond even these differences, students also vary in other areas: learning styles, readiness levels, interests, family traditions, socioeconomic status, years of formal schooling, background experiences, and special needs. “The diverse student community can be conceptualized as a wonderful and exciting element of the world we live in and not as a hindrance to the educational process” (Sanchez, 1995). The answer to the diverse nature of today’s schools cannot be met with simple inclusion of multicultural days and the teaching of the same cultural-relevancy lessons over and over again. “A total curriculum transformation needs to take place where the critical issues of diversity and multiculturalism are integrated into all aspects of students’ academic achievement, social skills development and relationship with the community at large” (Sanchez, 1995). Thus, instruction in schools today needs to support the needs of these diverse learners. While science concepts are internationally held, the teaching methods used must meet the needs of English language learners and students with varying levels of readiness and learning styles.

Teacher Support
Teachers today are responsible for ensuring students not only understand content knowledge, but also comprehend content through difficult texts. The more recent emphasis on content-area vocabulary and reading skills requires teachers to use new strategies in science instruction. Teachers also have limited time and resources for planning and implementing this instruction. Moreover, the diverse student body entering schools today need a variety of instructional methods. Therefore, teachers need science curricula that will help them easily implement effective science instruction that meets the needs of diverse learners.

In the past, local constituents often influenced schools in making instructional decisions. Today, however, political pressure comes from the federal level, and teachers are held accountable for meeting national benchmarks for instruction (Elmore, 1997). These changing pressures place new demands on teachers in the science classroom. *Discovering Science through Inquiry* provides the support teachers need to meet these challenges by including comprehensive lessons that meet national and state standards.

**Inquiry Science**

**Inquiry-Based Teaching**

Research on science instruction since the 1980s has supported inquiry-based teaching methods. “Inquiry into authentic questions generated from student experiences is the central strategy for teaching science” (National Research Council, 1996). In its official position statement on inquiry-based learning in science, the National Science Teachers Association (NSTA) encourages every teacher to make inquiry science a part of the daily curriculum at every grade level, noting that it is important to help younger learners become problem-solving learners. NSTA defines scientific inquiry as

> “the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Scientific inquiry also refers to the activities through which students develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world.”

**Benefits of Inquiry for Students**

According to NSTA, students learn science best when: they are involved in firsthand exploration and investigation and inquiry/process skills are nurtured; instruction builds directly on the student’s conceptual framework; content is organized on the basis of broad conceptual themes common to all science disciplines; and mathematics and communication skills are an integral part of science instruction. This position is highlighted in the National Science Education Standards (National Research Council, 1996), which view inquiry as “central to science learning.” As the standards explain, “when engaging in inquiry, students describe objects and events, ask questions, construct explanations, test those explanations against current scientific knowledge, and communicate their ideas to others. They identify their assumptions, use critical and logical thinking, and consider alternative explanations.”
Despite widespread agreement on the importance of inquiry-based learning, some teachers are still hesitant to adopt this pedagogical approach in their science classrooms for a variety of reasons. Some feel it is only appropriate for advanced students; others feel inadequately prepared for this type of instruction; still others are concerned about “managing” an inquiry-based classroom, in which some would say that students may be disruptive, pay less attention, socialize, or simply not participate. Yet, research proves false regarding all of these concerns. Discovering Science through Inquiry includes easy-to-use lessons with strategies for managing inquiry instruction in the classrooms.

Transitions to Inquiry-Based Instruction
Inquiry-based science lessons can take one of three approaches or range of practices: structured inquiry, guided inquiry, and open inquiry (Colburn, 2000). Teachers can incorporate these approaches based on the needs of the students or the objectives of the lesson. In some lessons, it is important for students to have a more structured or guided activity, while other lessons may be more suited for “free-ranging explorations of unexplained phenomena” (Huizak-Clark, 2003). Discovering Science through Inquiry provides lessons at varying levels of structure from open-ended inquiry activities to more structured inquiry. This gives teachers the opportunity to scaffold the development of students’ science process skills.

These stages of inquiry are not independent of each other; rather they exist along a continuum. Hence, teachers do not need to transition to open inquiry-based instruction all at once. “Both students and teachers alike need time to gradually make a transition from the more classical confirmation-type activities and lectures to open-ended activities characteristic of inquiry-based instruction” (Colburn, 2000).

An inquiry-based science classroom offers both teachers and students a wonderful opportunity to explore science in an exciting way. While there is a learning curve in the adoption of this approach both for teachers and for students, research confirms that inquiry-based methods of teaching not only improve student achievement in science (across all ability groups), but also increase student interest and excitement about science (Walker, 2007).
**A Model for Inquiry Teaching**

Engage, Explore, Explain, Elaborate, and Evaluate

One method for structuring an inquiry-based instructional approach is based on a model developed by Biological Science Curriculum Study (BSCS). This model employs the 5Es—engage, explore, explain, elaborate, and evaluate—and is based on a constructivist philosophy of learning. In this philosophy of learning, students build or construct their own understanding of new ideas based on what they already know. Each E represents part of a sequential instructional process or learning cycle designed to help students construct their own learning experiences and ultimate understanding of the topic or concept. The general goals and activities at each stage in the 5E model include:

- **Engage:** At this stage, teachers introduce a topic or concept with an intriguing, fascinating, or challenging question or demonstration designed to capture students’ interest, curiosity, and attention. At this stage, teachers do not seek a “right answer;” rather they prompt students to talk about what they already know about the topic (or think they may know) and discuss what else students would like to know.

- **Explore:** During exploration, students conduct various hands-on or problem solving activities and experiments designed to help them explore the topic and make connections to related concepts, often within groups or teams. During this stage, students share common experiences while the teacher acts as a facilitator, providing materials as needed and guiding the students’ focus.

- **Explain:** At this stage, teachers help students observe patterns, analyze results, and/or draw conclusions based on their activities and investigations. Teachers also define relevant vocabulary.

- **Elaborate:** In this stage, students build on the concepts or ideas they have learned and make connections to other related concepts and new situations.

- **Evaluate:** In the final stage, teachers evaluate, or assess, students’ understanding of the topic studied. This evaluation can be formal or informal but should demonstrate a clear understanding of what students have learned throughout the course of the lesson.

![5Es of Inquiry Model](image)

The 5’Es of science inquiry model are fluid allowing for assessment and re-teaching of concepts.
Prerequisites for Inquiry Learning

Research supports the use of inquiry teaching in the science classroom, but many teachers find it difficult to do. Fisher, Grant & Frey (2009) found that students need background knowledge before they can effectively learn science content using inquiry methods. They note that building background knowledge is one of the most important prerequisites for student learning in science. Discovering Science through Inquiry provides essential background knowledge for each lesson in the student inquiry handbook and on full color cards. Furthermore, this information is often represented both visually and in text form.

Assessment

Assessment is an important part of instruction in any content area. It is an ongoing, long-term process that can be conducted formally or informally. Although written tests are part of assessments, informal observations, student work, listening to groups communicate with one another, and science experiments can also be used to monitor students’ progress, identify students’ misconceptions, and identify their level of mastery for skills and concepts.

In order for students to achieve a high level of understanding of the scientific concepts presented, it is important that teachers provide students with the appropriate instruction, materials and support. Therefore, it is the responsibility of the teacher to conduct both formal and informal assessments to monitor students’ understanding and use that information to guide future instruction. The results of the assessments can help teachers determine whether re-teaching is necessary for some or all students, and whether or not it
is time to progress to the next lesson. The 5 E instructional model fluidly allows for assessment and re-teaching opportunities. Each lesson begins with an engaging activity that grabs the students’ attention. The Explore section of the lesson involves students’ investigation of the concept either independently or with some teacher guidance. Once exploration of the concept is complete, the teacher explains the concept and discusses the experiment with the students. Here, the teacher can informally assess whether students are beginning to understand that concept. If they are not, students should spend more time exploring the concept. If students understand the concept, the teacher should move to the Elaborate section of the lesson. Here, students make connections to other scientific concepts and extend what they have learned. Finally, when students are successfully making connections and extending the scientific concept, they can be formally evaluated on their knowledge.

Within the Discovering Science through Inquiry program, there is a diagnostic test for the whole program, as well as a less-extensive formal assessment at the end of each lesson. The diagnostic test can be used to assess students’ understanding of the concepts addressed in this resource. The test can be given as a pre-test before instruction from the unit begins.

Diagnostic assessments ensure students are taught at the most appropriate level.

Support for Teachers

Teachers also need support when implementing inquiry science. Jones and Eick (2007) note that teachers need extensive support from the bottom up in order to effectively teach science using inquiry methods. They suggest that professional development schools can support pre-service teachers by providing extensive coaching during lessons. But what support is provided for in-service teachers attempting to implement inquiry science methods? Jones and Eick found that teachers need support in scientific content knowledge, as well as in teaching processes. Discovering Science through Inquiry
includes clear, steps for each lesson in the teacher’s guide. Having an easy-to-follow teacher’s guide provides in-service teachers with essential support in leading the processes in an inquiry lesson. This is especially important when teaching inquiry science, because the methods often go against the traditional didactic pedagogy learned by most in-service teachers. Additionally, the teacher’s guide includes the subject-area information that teachers need to confidently teach the science content found in the lessons.

Background information is included in the teacher’s guide for each lesson. This strengthens teachers’ content knowledge to better lead science inquiry.

**Conclusion**

Science is a core subject area that many feel has been neglected in recent years. Educators need new methods and resources for teaching science given the constraints they feel in today’s educational climate. Research has identified the constructivist model of inquiry teaching as the most effective method for student learning. Lessons in *Discovering Science through Inquiry* provide five levels of inquiry for students. Materials in the program also include engaging content and texts written at a variety of reading levels to support diverse learners. Further, ongoing assessment is an essential component for data-driven instruction. Both formative and summative assessments are included in the program to guide teachers’ pedagogy. Overall, *Discovering Science through Inquiry* provides teachers with a comprehensive program to assess and meet the needs of all students for key science content topics.
The following references were employed in the creation of this research-based program:


