Welcome to Project-Based Inquiry Science!

Welcome to Project-Based Inquiry Science (PBIS): A Middle-School Science Curriculum!

This year, your students will be learning the way scientists learn, exploring interesting questions and challenges, reading about what other scientists have discovered, investigating, experimenting, gathering evidence, and forming explanations. They will learn to collaborate with others to find answers and to share their learning in a variety of ways. In the process, they will come to see science in a whole new, exciting way that will motivate them throughout their educational experiences and beyond.

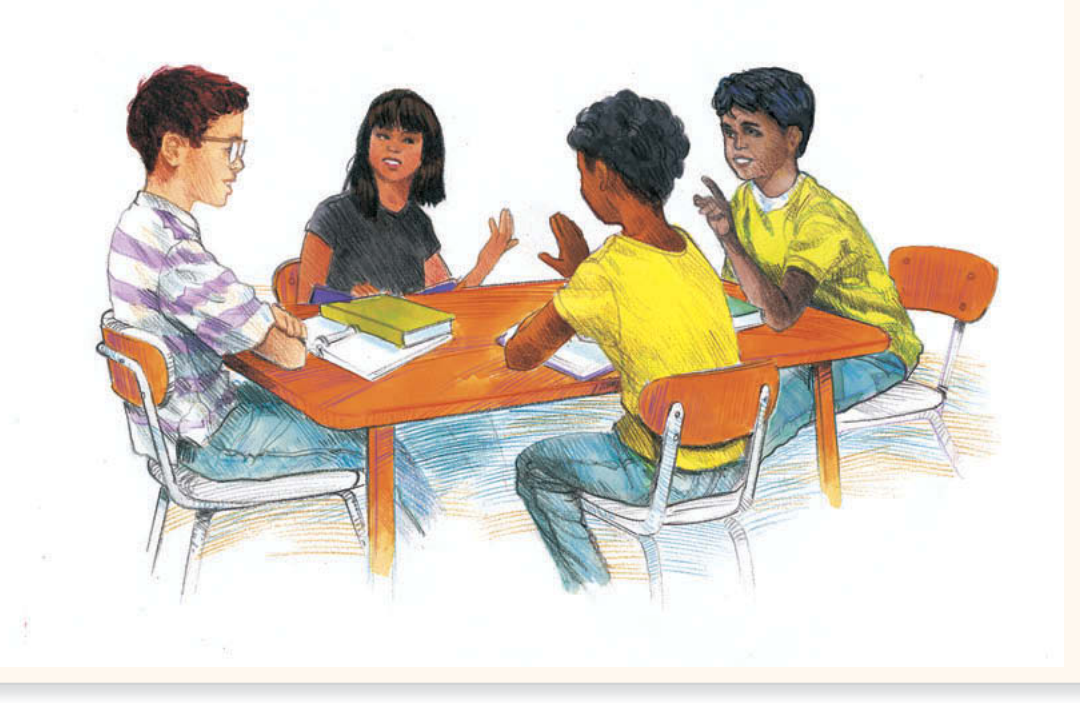
What is PBIS?

In project-based inquiry learning, students investigate scientific content and learn science practices in the context of attempting to address challenges in or answer questions about the world around them. Early activities introducing students to a challenge help them to generate issues that need to be investigated, making inquiry a student-driven endeavor. Students investigate as scientists would, through observations, designing and running experiments, designing, building, and running models, reading written material, and so on, as appropriate. Throughout each project, students might make use of technology and computer tools that support their efforts in observation, experimentation, modeling, analysis, and reflection. Teachers support and guide the student inquiries by framing the guiding challenge or question, presenting crucial lessons, managing the sequencing of activities, and

eliciting and steering discussion and collaboration among the students. At the completion of a project, students publicly exhibit what they have learned along with their solutions to the specific challenge. Personal reflection to help students learn from the experience is embedded in student activities, as are opportunities for assessment.

The curriculum will provide three years of piloted project-based inquiry materials for middle-school science. Individual curriculum units have been defined that cover the scope of the national content and process standards for the middle-school grades. Each Unit focuses on helping students acquire qualitative understanding of targeted science principles and move toward quantitative understanding, is infused with technology, and provides a foundation in reasoning skills, science content, and science process that will ready them for more advanced science. The curriculum as a whole introduces students to a wide range of investigative approaches in science (e.g., experimentation, modeling) and is designed to help them develop scientific reasoning skills that span those investigative approaches.

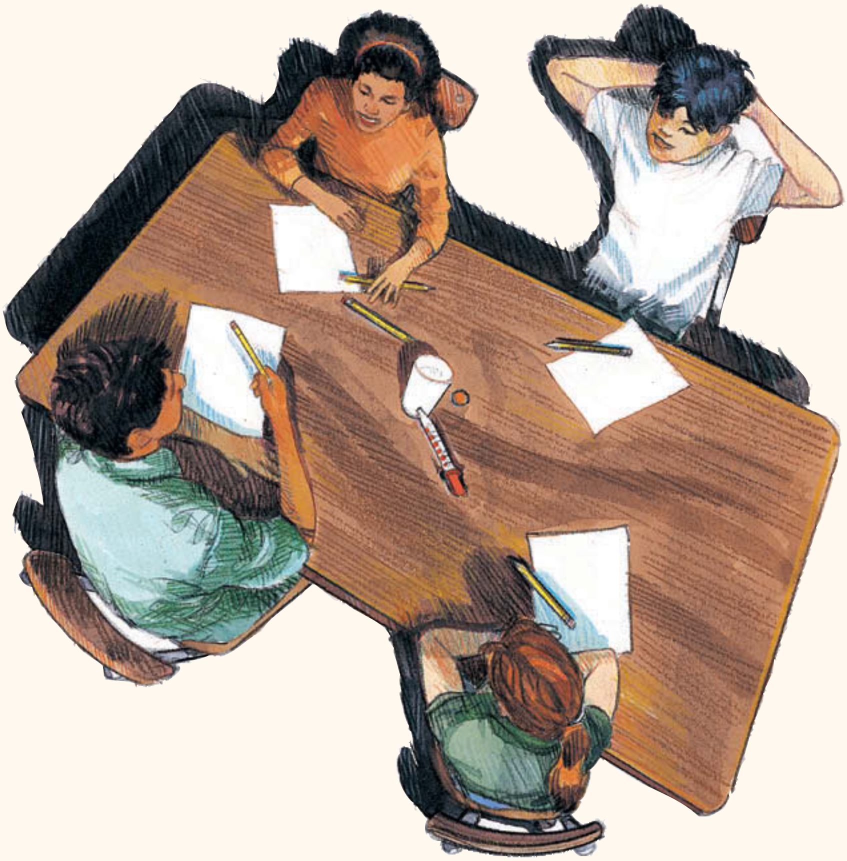
Technology can be used in project-based inquiry to make available to students some of the same kinds of tools and aids used by scientists in the field. These range from pencil-and-paper tools for organized data recording, collection, and management to software tools for analysis, simulation, modeling, and other tasks. Such infusion provides a platform for providing prompts, hints, examples, and other kinds of aids to students as they are engaging in scientific reasoning. The learning technologies and tools that are integrated into the curriculum offer essential scaffolding to students as they are developing their scientific reasoning skills, and are seamlessly infused into the overall completion of project activities and investigations.



Standards-Based Development

Development of each curriculum Unit begins by identifying the specific relevant national standards to be addressed. Each Unit has been designed to cover a specific portion of the national standards. This phase of development also includes an analysis of curriculum requirements across multiple states. Our intent is to deliver a product that will provide coverage of the content deemed essential on the widest practical scope and that will be easily adaptable to the needs of teachers across the country.

Once the appropriate standards have been identified, the development team works to define specific learning goals built from those standards, and takes into account conceptions and misunderstandings common among middle-school students. An orienting design challenge or driving question for investigation is chosen that motivates achieving those learning goals, and the team then sequences activities and the presentation of specific concepts so that students can construct an accurate understanding of the subject matter.



Inquiry-Based Design

The individual curriculum Units present two types of projects: engineering-design challenges and driving-question investigations. Design-challenge Units begin by presenting students with a scenario and problem and challenging them to design a device or plan that will solve the problem. Driving-question investigations begin by presenting students with a complex question with real-world implications. Students are challenged to develop answers to the questions. The scenario and problem in the design Units and the driving question in the investigation Units are carefully selected to lead the students into investigation of specific science concepts, and the solution processes are carefully structured to require use of specific scientific reasoning skills.

Pedagogical Rationale

Research shows that individual project-based learning units promote excitement and deep learning of the targeted concepts. However, achieving deep, flexible, transferable learning of cross-disciplinary content (e.g., the notion of a model, time scale, variable, experiment) and science practice requires a learning environment that consistently, persistently, and pervasively encourages the use of such content and practices over an extended period of time. By developing project-based inquiry materials that cover the spectrum of middle-school science content in a coherent framework, we provide this extended exposure to the type of learning environment most likely to produce competent scientific thinkers who are well grounded in their understanding of both basic science concepts and the standards and practices of science in general.

Evidence of Effectiveness

There is compelling evidence showing that a project-based inquiry approach meets this goal. Working at Georgia Tech, the University of Michigan, and Northwestern University, we have developed, piloted, and/or field-tested many individual project-based units. Our evaluation evidence shows that these materials engage students well and are manageable by teachers, and that students learn both content and process skills. In every summative evaluation, student performance on post-tests improved significantly from pretest performance (Krajcik, et al., 2000; Holbrook, et al., 2001; Gray et. al. 2001). For example, in the second year in a project-based classroom in Detroit, the average student at post-test scored at about the 95th percentile of the pre-test distribution. Further, we have repeatedly documented significant gains in content knowledge relative to other inquiry-based (but not project-based) instructional methods. In one set of results, performance by a project-based class

in Atlanta doubled on the content test while the matched comparison class (with an excellent teacher) experienced only a 20% gain (significance $p < .001$). Other comparisons have shown more modest differences, but project-based students consistently perform better than their comparisons. Most exciting about the Atlanta results is that results from performance assessments show that, within comparable student populations, project-based students score higher on all categories of problem-solving and analysis and are more sophisticated at science practice and managing a collaborative scientific investigation. Indeed, the performance of average-ability project-based students is often statistically indistinguishable from or better than performance of comparison honors students learning in an inquiry-oriented but not project-based classroom. The Chicago group also has documented significant change in process skills in project-based classrooms. Students become more effective in constructing and critiquing scientific arguments (Sandoval, 1998) and in constructing scientific explanations using discipline-specific knowledge, such as evolutionary explanations for animal behavior (Smith & Reiser, 1998).

Researchers at Northwestern have also investigated the change in classroom practices that are elicited by project-based units. Analyses of the artifacts students produce indicate that students are engaging in ambitious learning practices, requiring weighing and synthesizing many results from complex analyses of data, and constructing scientific arguments that require synthesizing results from multiple complex analyses of data (Edelson et al, 1998; Reiser et al, 2001). Students are engaged in planning, performing, monitoring and revising their investigations, and reporting on their investigation processes as well as their results (Loh et al. 1998). In general, the classrooms engaging in project-based activities reveal substantial moves toward a scientific discourse community in which students focus on arguing from evidence, critiquing ideas, and conjecturing, rather than simply reporting on what they have read or been told (Tabak & Reiser, 1997).