InquirySpace Teacher Guides: Project Overview

The InquirySpace (IS) project has pioneered a set of tools that allow students to look closely at real and virtual systems to discover patterns and make predictions. This is extremely important, because these tools allow students to undertake a wide range of sophisticated investigations of their own design.

As scientists and educators, we are often taken aback by simplistic assumptions in curricula that purport to teach students about the process and practice of science. Now that the Next Generation Science Standards (NGSS) have increased the importance of this dimension of science learning, it is essential that science education get this right. Science proceeds by searching for patterns and formulating theoretical explanations for the observed patterns. Through IS we want to make it possible for high school students to experience authentic science investigations that incorporate these features.

We protest the prevalence of the “hypothesis testing” paradigm, often taught as “the scientific method,” wherein students dream up a hypothesis and then test whether it can be rejected. While sophisticated forms of hypothesis testing are used in the social sciences and medicine, it is seldom the model used in other fields of science research. Teaching this exclusively conveys an inaccurate and unrealistic image of science research.

We are pleased that the NGSS do elevate the practices of science and engineering to equality with disciplinary core ideas and crosscutting concepts, itemizing eight science and engineering practices and including several in each detailed standard. However, as educators become familiar with these practices, we foresee the need for a more extensive focus on complete, independent student investigations that cohesively integrate all eight practices.

Of course, meaningful student-originated investigations have a precarious role in the classroom because they are very challenging for teachers. There are many barriers: students lack the background, skills, and incentives to undertake their own investigations, and teachers are concerned about the time, intellectual challenges, space, and equipment required to support student projects. IS explores a collection of strategies and resources for overcoming these barriers and makes it possible for teachers to offer opportunities for authentic student research in typical classrooms. Our overall goal in creating these strategies and resources is to research how they can help students engage deeply in extended scientific investigations and to share our findings and design principles with the science education community.

IS takes a fresh look at how to give students an authentic research experience, complete with data collection and analysis, based on both physical and virtual experiments. Our challenge is to design an integrated cyber infrastructure and a learning sequence that permits students to undertake significant scientific investigations. This way of thinking about student research draws from two well-established lines of study in the learning sciences. On the one hand, employing and analyzing results from experiments lends itself to learning through statistical reasoning and its consequent skills and knowledge. On the other hand, explaining the patterns in the data requires causal or mechanistic reasoning.

Technological support is central to the IS approach. Project software combines data acquisition using sensors, simulation-generated data from NetLogo and Next-Generation Molecular Workbench (Next-Gen MW) models, and a powerful data analytics environment called the Common Online Data Analysis Platform (CODAP), a web-based software package that evolved from Fathom and was developed through the NSF-funded DataGames project. IS has embedded simulations and sensor data collectors in CODAP to aid students in various steps in the experimental process including gathering, visualizing, and analyzing data from multiple sources.

This combination of technologies creates a flexible environment that students can use for a wide range of their own investigations. The software produces time-series graphs for individual runs generated by real or virtual experiments. One or more outcome measure (i.e., distance traveled, final temperature, frequency) is computed from each run. Students can generate parameter space graphs to analyze data from multiple runs. Each point in the parameter space represents one outcome of a single run plotted against one of the values of the parameters that were used during the run (i.e., friction, mass, or starting height). This approach is quite general; it allows students to answer questions of the form, “How does changing this input influence the outcome?”

A learning sequence is also central to achieving the IS goal of supporting independent student projects. The project uses a scaffolded sequence of increasingly open-ended computer-based activities using games, sensors, and computational models to develop student investigative skills. To simplify their integration into traditional course instruction, the activities are suitable alternatives to standard treatments of common physical science content such as motion, oscillation, and friction. Students can easily expand from the scaffolded activities to explore related questions using the same models, sensors, and physical equipment.