EDUCATION WEEK
Published Online: October 8, 2013
Published in Print: October 9, 2013, as **Students Learn by Arguing in New-Style Science Labs**
Includes correction(s): October 14, 2013

Students Learn by Arguing in Science Labs

Studies suggest deeper learning may result

By Sarah D. Sparks

Washington

Back to Story

Teaching students to argue, question, and communicate more like real scientists may also help them understand scientific concepts more deeply, according to several ongoing research projects highlighted at the Society for Research in Educational Effectiveness conference held here last month.

Scientific argument and inquiry skills—as separate from basic science-concept knowledge—are gaining a higher profile in science classes, as schools work to align their instruction with common content standards.

Both the Common Core State Standards for reading and mathematics and the Next Generation Science Standards have increased the focus within their disciplines on skills such as constructing and evaluating arguments, complex communications, disciplinary discourse, and critical thinking, said James W. Pellegrino, a co-director of the Learning Sciences Research Institute at the University of Illinois-Chicago.

"Although some think of these as general cognitive competencies, it turns out that reasoning and argumentation have to be disciplinary-based," Mr. Pellegrino said. "Reason and argumentation in literature is not the same as it is in history, is not the same as it is in science."

Eight-Step Process

Florida State University's laboratory school and local Gainesville-area secondary schools are testing a new method to teach reason and argumentation directly.

In a model called "argument-driven inquiry," each laboratory task involves an eight-step process, beginning with the teacher presenting a problem and small groups of students choosing on their own method and experimental approach to investigate it.

The students collect and analyze their data and develop arguments to present to the rest of the class. Based on those discussions, the students may collect more data, reflect on their findings, and write up an "investigation report" that has to go through a double-blind peer review process, modeled on the peer review boards that professional journals use to screen scientific papers submitted for publication. Each student then revises his or her work and submits a final report.

In a pilot comparison study of 265 8th grade students in 16 classes at both the laboratory school and regular district-run schools, researchers at the university's Center for Educational Research in Mathematics, Engineering, and Science found students using the traditional lab model engaged in more structured lab tasks than those in the argument-driven labs, but the latter labs went deeper during each task.

Students in the argument-driven inquiry labs designed experiments, argued from evidence, and gave oral presentations as part of every lab task.

By contrast, students in traditional labs designed their own investigations 17 percent of the time or less, argued based on evidence in 7 percent to 20 percent of lab tasks, and gave oral presentations in only 7 percent to 10 percent to lab tasks.

After a year, the students in both lab models significantly improved their knowledge of scientific concepts, but only the students in the argument-driven inquiry labs had improved in science writing and in their understanding of the nature and development of science knowledge.

Moreover, the students who were taught in the pilot labs showed nearly twice as much improvement in their ability to use and generate scientific explanations and arguments as the students in the traditional labs.

"From this, we think [argument-driven inquiry] demonstrates promise, that there's some potential there to enhance students' science proficiency," said Jonathon Grooms, a co-author of the study and a senior research scientist at the Center for Educational Research in Mathematics, Engineering and Science.

Intellectual Messiness

Moving toward argument-driven lab models could mean a shift in how students experience science, other researchers said.

Real laboratory work is messy: Theories fall apart during experiments, teammates disagree over interpreting the results, and data don't always neatly answer the question.

By contrast, students often avoid intellectual messiness in traditional school science labs, according to another analysis presented at the conference by researchers Janice Gobert and Juelaila J. Raziuddin of Worcester Polytechnic Institute in Massachusetts and Kenneth R. Koedinger, a computer science psychologist at Carnegie Mellon University in Pittsburgh.

They found that middle and early high school students often avoid setting a hypothesis that could be rejected, try to design and conduct experiments that would confirm biases they already hold, and reject evidence from an experiment that contradicts what they thought going into it.

Unmasking Misconceptions

The researchers used an online science homework platform to tweak the way 145 8th grade students recorded an experiment log. In 27 percent of the logs, for example, students correctly collected data during the experiment and entered a "scientifically accurate" interpretation of those data. But when asked to explain their findings, the students showed misunderstandings of the experiment.

The vast majority of these students' descriptions showed that they privately—and incorrectly—interpreted the results to confirm their initial hypotheses.

Though science, technology, engineering, and math programs have gained popularity in schools as a career-readiness issue, developing an understanding of the scientific process and scientific arguments is critical for students "regardless of whether we get them excited about a STEM career," said Heidi Schweingruber, the deputy director of the board on science education at the National Research Council, who commented on the studies but was not part of them.

"We don't need everybody to be a Ph.D. scientist or engineer," Ms. Schweingruber said. "What we need is a citizenry that really appreciates [scientific learning], ... that understands it and can use it to make decisions."

Coverage of informal and school-based science education, human-capital management, and multiple-pathways-linked learning is supported by a grant from the Noyce Foundation, at www.noycefdn.org. Education Week *retains sole editorial control over the content of this coverage.*

Vol. 33, Issue 07, Page 6