

PDF of article, **Capturing Joy: "K-12, I Do Science,"** by Barbara Jaquish,
published in University of Arkansas *Research Frontiers*, Fall 2007

7 pages, starting below

Capturing Joy: "K-12, I Do Science"

by Barbara Jaquish
December, 2007

A partnership between K-12 teachers and the University of Arkansas is improving science and math learning through

inquiry-based instruction and has the potential to be a model for improving science and math education in the middle schools. The program, "K-12, I Do Science" or KIDS, has earned a second round of funding from the National Science Foundation with an eye toward institutionalizing the program.

The program was initiated in 2001 by faculty in physics, engineering and education with teachers in regional public schools. While the initial NSF funding was aimed at the teaching and communication skills of graduate student fellows, the program has grown into a partnership that also benefits middle school teachers and students. Everyone involved - faculty, fellows and teachers - recognizes the importance of providing the best possible opportunities for middle school students to really learn science and math.



"The basic lesson to teach kids about science is that we learn by asking questions about nature, observing nature and thinking carefully about nature's answers."

The KIDS team includes Greg Salamo, Gay Stewart and Art Hobson from the physics department in the J. William Fulbright College of Arts and Sciences and Ronna Turner and Paul Calleja from the College of Education and Health Professions. Caroline Beller, formerly with the department of curriculum and instruction, returns each summer to train graduate student fellows in pedagogy and science and math standards. The program's director is Morgan Ware, a physicist. Lynne Hehr from the Center for Math and Science Education and mathematics professor Bernard Madison also have participated.

Salamo credits the rich mixture of people and disciplines for making the program work. The evaluator was on board from the beginning and the university faculty members brought in teachers to help write the proposal. The original proposal was the product of principals, superintendents, teachers, education specialists and scientists.

"It's a pleasure to find people with such an important goal working together," Salamo said. "The middle school administrators are supportive, and the passion of the teachers going beyond the call of duty is very heartwarming."

Recognizing Good Science

"I would argue today that knowledge in science for everyone is as important as reading, writing and arithmetic," said Salamo.

Stewart, who specializes in physics education, echoes his sense of urgency: "Our world is getting to be more and more technically challenging. You don't have to know all the science, but you have to know what to look for to understand good science. You're a better part of society and the world is a safer place if we understand science. It opens doors, and K-12 is the place we need to be opening up those doors to students."

KIDS involves the inquiry method of instruction, a learn-by-doing approach in which students actively engage their natural curiosity in learning advanced science and math concepts. It has earned the support of teachers, parents and school administrators and has contributed to improved test scores for middle school students. A four-week summer training workshop on the University of Arkansas campus provides graduate students and teachers with training in the inquiry method of instruction with the goals of increasing teachers' knowledge base in advanced science and mathematics, of increasing graduate fellows' ability to communicate their knowledge of the sciences, and of providing teachers with assistance in developing inquiry-based activities to teach Arkansas middle school math and science standards.

During the school year, the graduate fellows from fields such as physics, microelectronics-photonics, biology, chemistry, biochemistry, engineering and mathematical sciences spend 10 hours per week in the middle school

classroom, team-teaching with their K-12 teacher partners using inquiry methods. In its first five years the KIDS program has funded 38 graduate students and 27 K-12 teachers.

The KIDS program is funded by a \$1.5 million GK12 award from the National Science Foundation combined with \$1.25 million in matching funds from the university. After the first five years of funding, the NSF awarded the KIDS program a second six-year grant with the goal of institutionalizing the program. The university and the public school partners have committed resources to continue the KIDS program after the NSF funding runs out.

While the NSF grant is focused on the fellows and developing their ability to communicate about science to non-scientists, Turner, who had taught math in grades six through 12, thought about the effect on the schools and the boon to teachers of having a fellow bring advanced content and lesson ideas into the classroom.

"It's not just the training that is valuable," Turner said. "Modeling and mentoring are important, too. The fellows do inquiry all the time. All their research is inquiry. They just need to learn to explain science in contemporary language, not specialized terminology."

Inquiry Learning: What and How?

Stewart says that if you ask 20 educators about the inquiry method, you'll get 22 definitions. Turner recently presented a paper that described an inquiry learning system as one in which students "are encouraged to imagine and test out their predictions in the process of experiential learning." Teachers facilitate the process. The level of inquiry in a classroom can vary from a low level of student input, with the teacher showing students how the inquiry process works, to student-directed inquiry, in which the students "decide which hypotheses to test and how to design and conduct the study."

"The important thing is that it's not just *hands-on*," Stewart said, "it's *minds-on*."

When students engage in inquiry in at least some of the curriculum, Stewart said, "They are less passive. They are not just assembling facts, and they learn more."

Hobson said the method is effective because the students are involved and have to think for themselves. With an inquiry-based lesson, he said, "The students must engage with the universe rather than with the teacher's words."

Young people have to learn to think like scientists, Hobson said. They need to learn to observe the environment, experiment, think about the results and try to put together general principles.

"The basic lesson to teach kids about science," he said, "is that we learn by asking questions about nature, observing nature and thinking carefully about nature's answers."

Graduate fellow Justin Mitchell said that one of the great advantages of inquiry-based education is that students are doing their lesson without knowing what the answer is.

"This is how science works," Mitchell said. "The people who find holes in theories and who find solutions are scientists."

"It's about having real curiosity and being a detective of nature," Salamo said. "In teaching by inquiry, we are trying to capture the feeling of joy



"Little girls are much more likely than boys to want to be able to say in words what's going on. The inquiry-based method encourages them: You have to be able to explain it. You have to figure it out and put it together and be able to explain why. The boys' confidence went

scientists feel when we solve something. It's not just a teaching method. It's an effort to capture that joy in the classroom."

up too. It's just that the girls caught up, and that was very exciting."

Stewart suggests that teachers use a "scaffolding" process to head students in the right direction, keeping in mind that some areas are really helped by inquiry while in others a teacher can just give students information. She uses a fourth grade lesson in electricity and magnetism as an example. Students begin by playing with the magnets. Wire and a battery are introduced, and the teacher provides scaffolding by suggesting that students wind the wire around a nail. By the end, the students can build an electric motor and speaker. While fourth graders may not be able to give the equations for why their motor works, Stewart said, "They can give a good qualitative explanation."

Jo Martinson, a math teacher at J.O. Kelly Middle School in Springdale, Ark., admits that sometimes her classroom looks chaotic.

"There's a risk in the classroom in doing inquiry-based learning. I had to ask, 'Is it really meaningful?' But it's been a wonderful experience. Sometimes you just have to let go and do some things not written in the book."

She notes that math is sometimes harder for students to relate to than science. Fellows have been helpful in showing students how they use math as a tool in their scientific research. While inquiry activities take more time, she finds that the students' understanding is so much deeper, and it seems to her that retention is better.

Her colleague, science teacher John Lilly, is enthusiastic about the expertise the graduate fellows have brought to his classroom. Besides offering fresh ideas and scientific knowledge, the fellows can bring useful resources - like liquid nitrogen - into the classroom.

Most important, he said, "The kids just get so fascinated, and they are really learning. They're learning to think in a new way."

More Fun than CSI

Television shows everyone what firemen, doctors and crime scene investigation technicians do, but most middle school students have little idea what a scientist does. Salamo wants students to know that science is "more fun than CSI, and it can make a big difference in everyone's life."

Students in a KIDS classroom work with fellows, who are aspiring scientists, and together they do science. Salamo hopes they are learning that anyone can do science and that "it's not just for brainy people."

The students gain a broader perspective on who scientists are and what they do. Mitchell, who studies molecular spectroscopy theory at the university, thinks it's particularly important for students to see scientists in their classrooms all year, rather than as an expert who "swoops down" for a presentation.

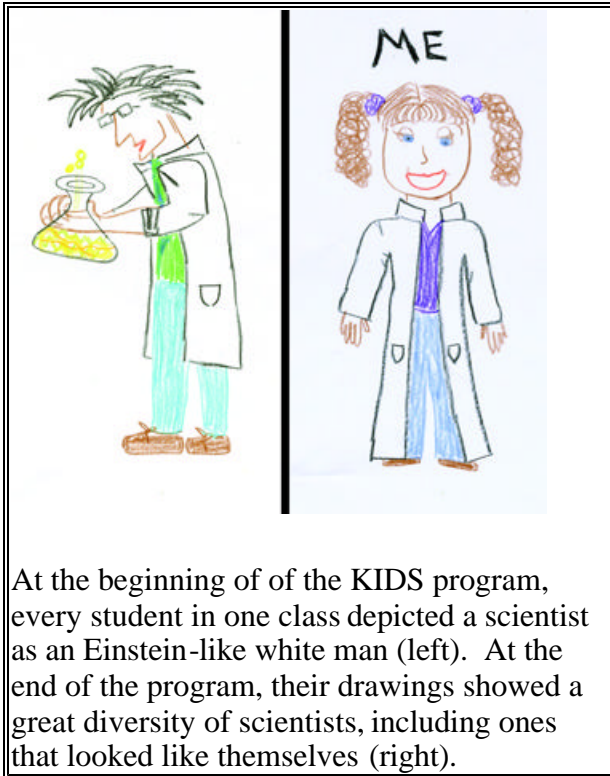
"The graduate students are not PBS scientists," Mitchell said. "We're not bigger than life and most importantly, we're not bigger than those students' lives. When I talk to middle school kids, the first thing I want them to know is, it's easy."

Susan Grisham is a second year GK-12 fellow who studies chemistry and, in particular, ligand synthesis for nanocrystal applications. In the fall of 2006, she helped Farmington middle school sixth graders develop critical thinking skills, mapping techniques and some basic analytical testing skills through an engrossing CSI activity. While that was a popular activity, she really made her mark in Ruth Mobley's classroom at Holt Middle School in Fayetteville during her first year as a fellow.

"I'm known as the scientist who blew a hole in the ceiling tile with an ethanol cannon. Now we've moved that lesson

outdoors," she admits with a laugh.

The KIDS team has a favorite story from the early years of the program to show the fellows' effect on students. At the beginning of the school year, a graduate student fellow asked her middle school students to draw a picture of a scientist. Every drawing was of an Einstein-like white man. When she repeated the exercise at the end of the year, she got a lot of drawings that looked like her, and many students drew pictures that looked like themselves. One girl handed in a drawing of a female scientist labeled "Me."



At the beginning of the KIDS program, every student in one class depicted a scientist as an Einstein-like white man (left). At the end of the program, their drawings showed a great diversity of scientists, including ones that looked like themselves (right).

it out and put it together and be able to explain why. The boys' confidence went up too. It's just that the girls caught up, and that was very exciting."

Evaluation: First Do No Harm

Turner agrees that an increase in the use of "hands-on and minds-on" learning promotes active learning. She also looks for quantifiable results.

"It is important to note that the use of inquiry alone is not the focus of the KIDS program; it is necessary that the inquiry activities address specific math and science content standards in order to be effective at increasing student knowledge," she said. "A preponderance of math and science research shows that the experiential part is not key. What is key is using the experiential curriculum to convey math and science content."

The evaluation component was part of the KIDS grant proposal from the beginning, something that Turner said is rare in her experience, and is part of why she calls this "my favorite program I have ever worked on in my entire life."

"We had a good idea and we have a good evaluator. She *listens* to hear what it is the principal investigators need," Salamo said. "For example, it's not enough to say that grades were higher. We need to know *why* in order to make a difference. Generally evaluators are just looking at the outcome and not the why."

Stewart believes that while inquiry-based learning is effective for everyone, it is particularly effective for girls:

"The inquiry method is more empowering. I found in my university classes that the confidence of girls goes way up. In university physics at the end of the first semester, we saw that, regardless of ability, male students are more confident than the females in what they thought their understanding and ability in sciences was.

"Then we put them in a classroom where they had to reason things out, to really understand them, to be able to explain them and figure out what was going on. All of a sudden the difference in confidence - which was statistically significant - went away."

While she found that male students assumed they understood the problem if they could memorize the formula and plug factors into it, girls looked at it differently.

"Girls worry at things a little bit more," she said. "They want to know *why* that works. Little girls are much more likely than boys to want to be able to say in words what's going on. The inquiry-based method encourages them: You have to be able to explain it. You have to figure

Citing the richness of being intimately involved with the program she was evaluating, Turner added, "I think we have to look at the bad as well as the good. We've got to report it all so we can figure out what is going on. If the program's not working, I don't want it out there. If it's going badly, I don't want my own kids in that classroom."

In evaluating KIDS, Turner started from the premise that using inquiry in the classroom must do no harm. For example, scores on standardized tests in the KIDS classrooms must be as good as - if not better than - the scores in conventional classrooms. While covering the same content in the same weeks, "the challenge is to create the inquiry within the lessons," Turner said.

As a whole, students in KIDS classrooms showed greater improvement in test scores than their peers in conventional classrooms. Students in KIDS classrooms showed improvements for both males and females, minority and non-minority students, and low performing and high performing students.

Over the course of the program, teachers developed increased confidence in their own knowledge of advanced science and math concepts while obtaining assistance in incorporating inquiry learning into classroom instruction.

In addition to monitoring student scores on standardized tests, evaluators had several forums for collecting data. Anecdotal evidence came from the weekly fellows' meetings and monthly teachers' meetings with university organizers. Training was adjusted slightly from year to year based on teacher feedback. Classroom observation by trained evaluators offered additional information and led to other changes, such as increased emphasis on state content standards in training. Turner also shared particularly creative lessons at the monthly teacher meetings.

"The teachers and fellows didn't realize how exciting some of the things they do are," Turner said.

For example, Turner observed Lilly using inquiry in a regular lesson that involved learning information from a textbook. He could have instructed the students to read the passage and then asked them some questions. It took him no longer to show students how to read critically:

"Rather than just tell the students to read individually, he modeled how to read a passage of a science textbook. He and the students read together. At times he would stop and say 'Now what would I ask myself when I read this?'"

Calleja also suggests opportunities for collaboration among teachers throughout the school. He had been an elementary physical education teacher earlier in his career and sees ways in which science and math could be integrated into PE classes.

Data obtained by trained classroom observers show that when selected types of inquiry activities were used in the KIDS classrooms, more than 80 percent of the students were actively engaged in the lessons. More than 25 percent of the time, teachers incorporated the two highest levels of the inquiry method for these activities - activities that were initiated by teachers and facilitated by students or activities initiated and facilitated by students. Evaluators found student testing of hypotheses and manipulation of active learning tools to be the most successful procedures in the program to actively engage students in the inquiry learning process.

Turner also collected attitudinal data about confidence levels of teachers and fellows. By tracking the progress of teacher confidence, they were able to determine that at least two years of program participation worked best for teachers.

Mitchell's experience illustrates why the program is important to fellows, too. He'd always been interested in teaching in addition to research, and the KIDS program was his only opportunity for formal training in pedagogy. For him, the program was "a powerful recruiting tool," and the NSF fellowship was a major reason he chose the University of Arkansas.

"For a person interested in undergraduate education, the GK-12 program is perfect training. I was really surprised how well I could translate lessons from middle school to teaching undergraduates who are taking an introductory physics class but aren't science majors," he said. "It's a big investment in time, but what you get out of GK-12 is well worth it."

[Back to the Top](#)

Office of University Relations, University of Arkansas • 800 Hotz Hall, Fayetteville Arkansas, 72701

479-575-5555 • 479-575-4745 (fax)