Yvette Logan paces between computer pods in the quiet library at Steel Valley High School, south of Pittsburgh. Ten students click away on iMac personal computers. Logan has only 43 minutes for the basic chemistry lesson, and she has to share computer lab space with middle-school classes.

But today, Logan also is hoping to get her 10th- and 11th-graders to grasp what she thinks could be a great instructional tool: tutoring software that harnesses artificial intelligence to teach chemistry. Before she can use this 21st-century technology, however, Logan has to do what teachers have been trying to get adolescents to do for the past 200 years: Pay attention, sit still and read the directions.

A 10th-grade boy in a black T-shirt tips his chair back and asks Logan what he's supposed to do next. "All four on the floor," she says, then holds a worksheet in front of his screen. "Read the directions," she adds flatly. She's got it all mapped out for the students — if they follow her topic cues: covalent bonds, ionic bonds, positively charged ions called "cations."

By the end of the class, the students are starting to get it, some more than others. Tenth-grader Jen Sakanich is clicking on instructions about how to determine the number of cations in a strontium chromate molecule. Brittney Dulin, also in 10th grade, is figuring out how many valence electrons are in a series of compounds. None of this is easy, but the computer-based tutor is moving students step-by-step through progressions that will help them understand how these atoms are linked.

The software they're using is "Quantum Tutors," one of several high-tech innovations produced by "home-grown" educational technology companies flowering in western Pennsylvania. The firms are putting Pittsburgh on the map as a hub for transferring technology-based research and development into new tools for learning math, science and reading, as well as for gathering and analyzing data to improve student achievement. Helping to promote the industry through strategic grant making have been The Heinz Endowments and other foundations.

"It's not that we were interested in technology per se, but in the use of technology to improve school systems and improve teaching and learning, and to help teachers analyze student achievement," says Susan Brownlee, former executive director of the Grable Foundation, one of the region's major education funders that support various "ed-tech" efforts.

Now executive director of the Fine Foundation, Brownlee explains that philanthropic organizations are giving to these projects because the technology is finally sophisticated enough to deliver education on a student-by-student basis.

And the new tools are designed to help students and teachers address a range of learning problems. For example, nearly one-third of the students attending schools in many low-income city neighborhoods routinely fail to acquire grade-level skills in reading and writing, says Endowments Education Program Director Joe Dominic. Some have special learning needs requiring more than routine classroom instruction; others simply take more time to acquire specific

Reid R. Frazier is a Pittsburgh-based freelance writer. This is his first story for h.

AS EDUCATION TECHNOLOGY BECOMES MORE SOPHISTICATED, EDUCATORS, ENTREPRENEURS
AND FOUNDATIONS IN WESTERN PENNSYLVANIA ARE NURTURING
"ED-TECH" STARTUPS THAT CAN TAKE TUTORING SERVICES TO STUDENTS WHO NEED THEM.
BY REID R. FRAZIER PHOTOGRAPHY BY LISA KYLE

FROM CHALKBOARD
TO KEYBOARD

QUANTUM SIMULATIONS

YEAR FOUNDED	1998
LOCATION	MURRYSVILLE, PA.
FOUNDERS	BENNY G. JOHNSON, CO-FOUNDER, PRESIDENT AND CEO; REBECCA RENSHAW, CO-FOUNDER AND EXECUTIVE VICE PRESIDENT; DALE A. HOLDER, CO-FOUNDER AND CHIEF ACADEMIC OFFICER
WEB SITE	WWW.QUANTUMSIMULATIONS.COM
EMPLOYEES	10
STUDENTS SERVED	THE "QUANTUM TUTORS" ARE CURRENTLY BEING USED BY SCHOOL DISTRICTS IN PENNSYLVANIA, OHIO, CALIFORNIA, TEXAS AND KENTUCKY.

QUANTUM DEVELOPS ARTIFICIAL INTELLIGENCE TUTORING, ASSESSMENT AND PROFESSIONAL DEVELOPMENT SOFTWARE FOR CHEMISTRY, MATHEMATICS AND ACCOUNTING. ITS PROGRAMS, WHICH CAN BE USED IN THE CLASSROOM AND AT HOME, ARE DESIGNED TO EMPOWER EDUCATORS AND INSPIRE STUDENTS TO ACHIEVE MORE.

Using a laptop to do schoolwork is almost second nature for 17-year-old Kelly Lipovich. Kelly, a junior at Mars Area High School, north of Pittsburgh, was able to take advantage of the convenience of using the Quantum chemistry tutor at home last year to help her through that course.

skills. Administrators, teachers and parents are hard-pressed to find sufficient time to handle this challenge. Students usually fall behind and most don't catch up.

While human tutors are seen as one remedy, too often they are not readily available, Dominic points out. Many are under-prepared and rarely can work with the frequency, duration and intensity needed. Computer- or Web-based tutoring extends learning time beyond the traditional school day and affords students multiple opportunities to master essential information.

At Steel Valley High, Logan, who also tutors math and science after school, echoes that sentiment. She knows many of her students can't afford the $15 to $25 per hour it costs to hire a human instructor. She believes one-on-one interaction with a live teacher is the ideal way for a child to learn. "But that human won't be available at two or three in the morning," she says.

While tutoring software is still at the early stage of its evolution, it is increasingly used by students in pre-kindergarten classes through 12th grade. At the same time, determining how much of a difference educational software can make in improving students' learning has been a matter of debate.

In April, the U.S. Department of Education released first-year results from a study that found that students who used various reading and math software in the classroom did not perform significantly better on standardized tests than those who used other methods. Senior study director Mark Dynarski of Mathematica Policy Research in Princeton, N.J., says the 15 software packages selected had shown positive results in smaller studies, but results based on data collected from more than 9,000 students in the federal study were "nowhere near what people had found in the past." The second year of research will use the same teachers with new students to determine whether the products are more effective when teachers have more experience using them.

Makers of the software packages included in the study and groups supportive of education technology were critical of the findings. They contended that the results didn't take into account whether teachers used the software properly or for adequate lengths of time. They also questioned why the study only reported aggregated results, rather than explaining how each one of the curriculum packages fared individually.

Dynarski says the ed-tech industry association asked that the results for individual packages not be revealed so that the software makers would not be reluctant to participate in the study. Individual results will be released after the second year.

"The impact on student learning is an important issue," notes Dominic. "But the evaluation research in this field has not yet produced sufficient results to identify achievement trends for specific tutoring tools. I continue to have guarded enthusiasm for the value of computer- and Web-based learning."

Part of the Endowments' education strategy is to support advanced development of software that shows promise for helping students master essential skills in reading, math or science, or that collects and sorts data to enable administrators and educators to be more effective. While the individual grants have varied in size, the foundation has awarded $23 million in support to education technology projects through the past decade. And although the Endowments does not fund for-profit ventures, its investment in important research and development has enabled some ed-tech projects to evolve into business startups.

Among the most promising ed-tech companies in western Pennsylvania are those with direct education applications. This "intelligent tutoring" software uses powerful artificial intelligence technology to enable a computer to "think" the way a good teacher would. Students can get highly specific instruction in reading, math or science, even when good teachers aren't available.

Carnegie Mellon University and the University of Pittsburgh have spearheaded development of this type of software, and there is growing optimism among funders and educators about the local expansion of the industry.

"Pittsburgh was one of approximately two places in the world I could have done this kind of research," says Jack Mostow, a computer science professor at Carnegie Mellon and creator of "Project LISTEN's Reading Tutor," a software that uses voice recognition to tutor students in reading. "Within a few minutes' walk from my office, there's expertise in education, human computer interaction and cognitive psychology."

At Apangea Learning, Carey Noonan, 25, is one of 10 "live" tutors who work online with up to 500 students in any given week. A California University of Pennsylvania grad with a degree in secondary education and a math certification, Noonan has been with Apangea for about a year. The firm differs from many ed-tech companies offering tutoring services because it has employees who help students over the Internet with the practice exercises.

The Endowments contributed $250,000 toward the development of "Project LISTEN" software, which has the potential to become a business in the future.

"We've tried to be very selective in helping grow Pittsburgh's technology-based research and development and related commercialization of products," says Dominic. "Local talent appears to us as the best bet for advancing the development of new tools that promote learning."

One notable exception was funding to provide the Pittsburgh Public Schools with reading software from the Utah-based Waterford Research Institute in the late 1990s. In that case, Endowments staff found Waterford's software was the best available product for giving kids a jump on early literacy. The Endowments gave $1.56 million to help put the software into every elementary school and Head Start site in the district. A subsequent $1.35 million grant allowed 11 schools in Allegheny, Westmoreland and Mercer counties to purchase the software.

From school officials' perspective, such funding helps ease the sticker shock often caused by the price of new technology. School districts often lack the money to support innovation, notes Gerry Balbier, vice president of innovation programs for the ed-tech company Apangea Learning and a former senior program officer in education at the Endowments. "If you were to ask a superintendent or school board chair how much flexibility they have in their budget to spend on innovation, they're going to tell you 'Not much.' "

Kevin Willis, a chemistry teacher at Carmichaels High School in Greene County, about an hour south of Pittsburgh, agrees.

"When you can say all we're paying is the first 10 percent, that makes it a little easier for [administrators] to say 'yes,' " says Willis, a buoyant teacher whose students know his class as "Kevistry." His school has piloted software from local firms that include Quantum Simulations, maker of "Quantum Tutors"; Apangea; and Carnegie Learning, all with foundation support.

In fact, one of the ways foundations assist school district officials in acquiring educational software is to provide funding that allows the districts to gradually assume a higher proportion of a program's costs. For example, a $200,000 grant

that includes $150,000 from the Grable Foundation and $50,000 from the Endowments is helping Carmichaels and 10 other school districts in the region cover the expense of using the Quantum software for five years.
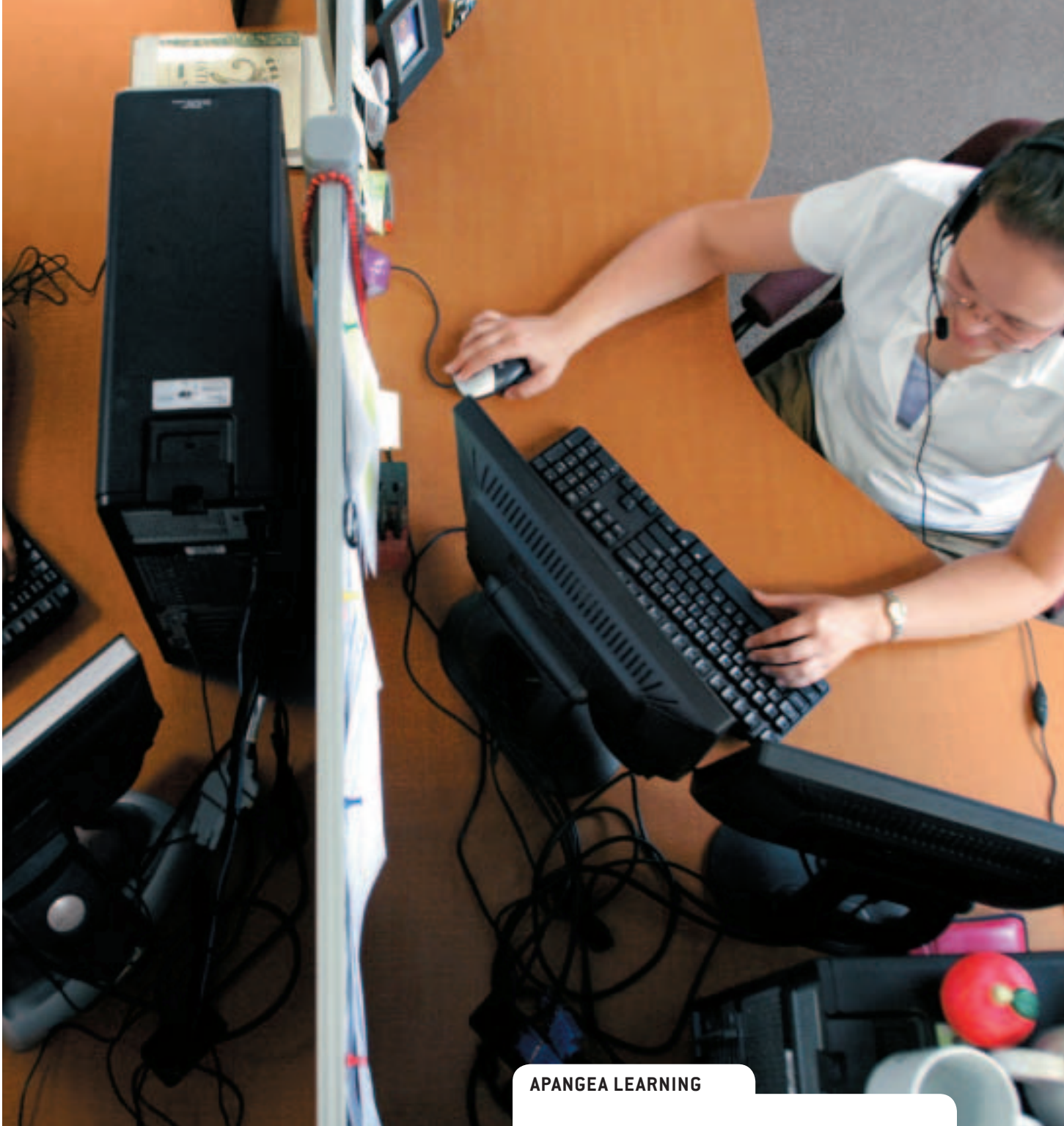
Benny Johnson, a Carnegie Mellon chemist and programmer who grew up on a dairy farm in south-central Kentucky, started Quantum in partnership with Dale Holder, his old high school chemistry teacher. The two looked for technology from around the globe to create their tutor. They found the perfect source just a few blocks from Johnson's office, at Carnegie Mellon's Human-Computer Interaction Institute. Researchers there had created the "Cognitive Tutor," a powerful math curriculum software designed from more than 20 years of research into how humans learn.

Building off of that software's technology, Johnson received a National Science Foundation grant to design a chemistry tutor. The firm, which partners its product with textbook companies, now provides software used by more than 10,000 students and is looking to expand into other subject areas.

Substantial research and development support from the Endowments and Grable also helped Apangea become a promising online tutoring company, with a focus on helping students develop better math skills and offering human tutors along with computerized ones.

Wearing a headset and staring at a screen filled with text boxes, message scrolls and diagrams, Carey Noonan looks like she's helping to land an airplane, communicating with a space shuttle or guiding Jack Bauer to a terror cell on a television episode of "24" rather than navigating Alexis Jackson through a maze of square roots.

As the Peabody High School ninth-grader struggles with an equation, Noonan slaps a calculator onto her desk in a downtown Pittsburgh office, taps in the square root of 50, then tells the teenager that she came up with a different answer. (It's a hair more than seven.) Alexis types in the correct answer from a computer lab inside a church basement, then signs off. By the end of the day, Noonan has helped about 100 students from five different states, in grades five through 12, all without leaving her chair.

APANGEA LEARNING

APANGEA LEARNING PROVIDES MATH TUTORING PROGRAMS THAT USE ARTIFICIAL INTELLIGENCE SOFTWARE AND HUMAN TUTORS TO TAILOR EXERCISES TO STUDENTS' NEEDS. THE FIRM EMPLOYS COGNITIVE SCIENCE TO HELP STUDENTS DEVELOP THE SKILLS TO SOLVE A WIDE RANGE OF MATH PROBLEMS.

CARNEGIE LEARNING

YEAR FOUNDED — 2002
LOCATION — PITTSBURGH, PA.
FOUNDERS — STEVE RITTER, KEN KOEDINGER, WILLIAM HADLEY; JOHN ANDERSON, ALBERT CORBETT
WEB SITE — WWW.CARNEGIELEARNING.COM
EMPLOYEES — 80
SCHOOLS SERVED — 475,000 STUDENTS IN MORE THAN 1,300 SCHOOL DISTRICTS ACROSS THE UNITED STATES

CARNEGIE LEARNING PUBLISHES A MATHEMATICS CURRICULUM AND SUPPLEMENTAL TUTORING MATERIALS FOR MIDDLE SCHOOL, HIGH SCHOOL AND POSTSECONDARY STUDENTS. THE COMPANY'S "COGNITIVE TUTOR" PROGRAMS INTEGRATE INTERACTIVE SOFTWARE SESSIONS, TEXT AND STUDENT-CENTERED CLASSROOM LESSONS.

Ninth-graders Gary Gabor and Lucy DeBor are engrossed in Carnegie Learning's Cognitive Tutor math software in a computer lab at Upper St. Clair High School, south of Pittsburgh. During classroom time, students tackle real-world exercises in a Carnegie Learning workbook that is similar to those provided by the software.

"I think this really is the wave of the future," she says. "It gives you a different flavor of what education means. You still have the human interaction between teacher and student, but you have the technology to support more things going on at once."

Louis Piconi and Stephan Mueller, a pair of local tech entrepreneurs, founded Apangea in 2002 with a simple idea: "Our core belief is that every student who needs tutoring should be able to get it," says Piconi, the company's CEO.

They licensed artificial intelligence developed by the U.S. Air Force. Then they tested their software on students in after-school centers, free of charge, for a year. The team began selling it in 2004, and the Endowments awarded a $100,000 grant to the community-based technology initiative 3 Rivers Connect to enable students from low-income families to use the software. Later that year, the Endowments and the Grable Foundation gave the Mon Valley Education Consortium a $225,000 grant to provide Apangea tutoring to poor students in 16 middle schools in the Pittsburgh region.

By combining artificial intelligence with a human tutor accessible via the Internet, Piconi and Mueller think they've found a happy medium between technology and one-to-one instruction. They also have been able to pare the cost of tutoring to $1 to $2 an hour and, so far, 30,000 students use it across the country.

In many ways, companies like Apangea and Quantum can credit much of their success to the pioneering efforts of Carnegie Learning, the area's first intelligent tutor company. Carnegie Mellon spun the company off in 1998 as a way to market the "Cognitive Tutor" math software. The Endowments provided support by funding a CEO search and helping the group develop a business plan to attract investors.

Unlike Quantum and Apangea's software, the "Cognitive Tutor" is a core curriculum, meaning students use it for their main lessons during class rather than as a supplement during or after school. Since its launch, the company has grown to 80 employees; 375,000 students use the "Cognitive Tutor," which is considered among the national leaders in educational software.

Still, Carnegie Learning has navigated some rough waters to find its feet in an educational publishing industry dominated by large textbook companies. In 2005, the company's board brought in Dennis Ciccone as the firm's third CEO. A business veteran and one of Carnegie Learning's original board members and investors, Ciccone helped stem the flow of red ink, boosted sales and now has the business growing again. Growth rates for the past two years are at 60 percent, and the company recently signed contracts with big districts in Chicago and Los Angeles.

Ciccone says the company is still learning to help schools overcome a kind of culture shock when using technology in classrooms. "You still see teachers who don't even want to touch it, won't even turn it on," he says.

The federal No Child Left Behind Act of 2002 has helped change this dynamic. The law mandates that all students be proficient in math and science by 2014.

"There's a lot of pressure on schools to do better now," says Steve Ritter, one of Carnegie Learning's co-founders and senior vice president of research and development. "Often that means considering doing things differently than they've done before."

The "Cognitive Tutor" also has caught the eye of the textbook industry. Two publishers offered to buy it last year. Carnegie Learning's board ultimately balked, in part because members didn't want to see the company leave the area and because they thought business had a good chance of taking off in this region. "They were very receptive to the question of 'Can we begin to build an industry here?'" says Ciccone.

It's a question that intrigues many as they ponder whether companies grown in western Pennsylvania ultimately will choose to stay.

"Once you have the germ of something that starts here, it doesn't really make sense to start it whole cloth somewhere else," says Christina Gabriel, who directs the Endowments' Innovation Economy Program. "There's really no reason why this place can't become a mecca for this industry." *h*